THURSDAY, JULY 1, 1915.

## PHYSICAL, CHEMICAL, AND ENGINEERING CONSTANTS.

*Tables Annuelles de Constantes et Données Numeriques de Chimie, de Physique et de Technologie.* Volume ii., Année 1911. Pp. xl+759. Price 28*s.* 6*d.* net. Volume iii., Année 1912. Pp. lii+595. (Paris: Gauthier-Villars et Cie.; London: J. and A. Churchill, 1914.) Price 28*s.* 6*d.* net.

THESE volumes are a continuation of the new annual tables of physical, chemical, and engineering constants, the publication of which was commenced by an influential International Committee in 1910; they contain the data for the years 1911 and 1912 abstracted from a very large number of scientific periodicals. One of their most commendable features is that memoirs are not passed over even when their titles do not indicate them as sources of new constants. The abstractors have indeed no light task in the collection of the large amount of information constituting in a single volume the results of a year's research by the laboratories of the entire world. While the basal language of the book is French, the preface, headings to the pages, and the excellent indexes are also printed in English, German, and Italian.

When the first volume of these "Tables Annuelles" was published one was inclined to look forward with dismay to the prospect of being obliged when requiring a physical constant to search for it not only in some general book of tables, but in a series of volumes, increasing in number each year. But during the short time which has elapsed since their publication, they have become indispensable to every well-equipped science library, it being understood that their use is supplementary to that of one or more of the standard works of reference. It may be of interest to point out that since the issue of vol. i. there have been published of works on physical constants the large work of the late Mr. Castell-Evans, the useful small book of Kaye and Laby, and the fine volume issued by the Société Française de Physique, edited by Profs. Abraham and Sacerdote; also a new edition of "Landolt and Börnstein," more bulky than ever, and two new editions of the well-known Smithsonian Tables, in the last of which the rather numerous printer's errors occurring in its predecessor have been corrected.

The two volumes under review bear signs that the experience gained by the compilers has enabled them to introduce a number of improvements, and a careful examination of the books has revealed only comparatively few errors.

One of the latter is that experience with an electrically heated salt-bath, employing a mixture of KCl and NaCl, indicated that Mr. Dutoit's figures on page 518 of vol. ii. for the conductivity of these mixtures at the higher ranges are given a hundredfold too great; $K \times 10^8$ at the head of the column should apparently be $K \times 10^6$.

The staggering statement on page 408 of the same volume that Cambridge tap water contains $135 \times 10^{12}$ grams of radium per litre would, if true, delight the heart of many others besides Sir J. J. Thomson and Mr. Satterly. Obviously $10^{12}$ should be $10^{-12}$.

A list of a few other inaccuracies has been sent to the compilers. In spite of these almost inevitable slips we have little fault to find with the volumes, the general usefulness of which is undoubted.

In vol. ii. the division relating to spectroscopy, consisting of more than 150 pages, is unusually complete. No fewer than 30 pages are devoted to the Zeeman effect alone, while the results of the work of King, of Duffield, and of Rossi on the effect of pressure are tabulated in detail.

In vol. iii. the ground covered seems to have been still further extended, large physiological and biochemical sections being added. It would not, however, be safe to presume that though one finds on page 488 "Lait—Densité 1·0270–1·0326" the heading a few pages later, "Propriétés des Laitiers" (page 530), implies that the milkman also has been included.

The volumes indicate how great is the progress now being made by research, and render much otherwise difficultly accessible material very generally available.

The compilers kindly offer in the preface to vol. iii. to place their services at the disposal of readers requiring further information as to data in periodicals to which they have not access.

In view of the necessarily bulky character of these volumes an excellent innovation is the issuing of a number of the more important sections of vol. iii. in separate parts. A reader can thus acquire the advantages of possessing the data on the portions in which he is specially interested, without being obliged to buy the whole work.

In conclusion, we venture to hope that the idea of the committee of issuing every five years or so a *critical* summary volume, in which an attempt will be made to sift out the wheat from the chaff and assess the relative value of the various discordant determinations, will not be lost sight of. The need for it becomes continually more apparent.

J. A. HARKER.



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## ELEMENTARY ZOOLOGY.

(1) *Zoology: An Elementary Text-Book.* By Dr. A. E. Shipley and Dr. E. W. MacBride. Third edition. Pp. xx+752. (Cambridge: At the University Press, 1915.) Price 12*s.* 6*d.* net.

(2) *Elementary Text-book of Economic Zoology and Entomology.* By Prof. V. L. Kellogg and Prof. R. W. Doane. Pp. x+532. (New York: H. Holt and Co., 1915.) Price 1.50 dollars.

(1) A NEW edition of "Shipley and MacBride" will receive a welcome from students and teachers of zoology, for the original work—published in 1901—took at once a distinct place among text-books on account of the freshness and individuality of the authors' method. The present volume exceeds in length its forerunner by 100 pages, and many improvements have been introduced. For example, the groups of the flatworms, nemertines, rotifers, and nematodes have been brought from their former position at the end of the volume following after the mammalia, and placed before the annelida. The arrangement, which startled readers of the first and second editions, was intended to emphasise the authors' opinion that these groups are not cœlomata, and this opinion is still set forth, perhaps too dogmatically, in the clear "Introduction to the Cœlomata" that precedes immediately the account of the annelids. The authors have accepted Goodrich's distinction—now familiar to zoologists—between true nephridia and cœlomoducts (such as the excretory tubes of arthropods, molluscs, and vertebrates). They also revert to the "orthodox" interpretation of the mammalian ear-ossicles, and in connection with this problem supply a valuable diagram of the temporal region of the skull in theromorphous reptiles for comparison with the mammalia. The book still neglects, to a great extent, palæontological as well as embryological facts, but these are invoked where questions of morphology and relationship are discussed. Indeed, the last half of the volume comprises an excellent introduction to the comparative anatomy of vertebrates. As regards systems of classification, there is always room for differences of opinion, but we believe that most students of the Mollusca will object to the removal of the Chitons from association with Chætoderma and Neomenia, and their replacement in the Gastropoda; while among the arthropods, the unnatural group of the "Myriapoda" is still retained, and appears in the same class with the insects and the peripatids—an altogether indefensible association. The introduction has been lengthened by two pages for the inclusion of a necessarily imperfect sketch of recent work on heredity.

(2) Indeed the writers of comprehensive modern text-books must be constantly faced with the question whether it is better to discuss some subject imperfectly or to leave it alone altogether. Profs. Kellogg and Doane have, with considerable success, attempted, within the limits of a handy volume, to furnish their students with a guide not only to the facts and principles of zoology but to its applications to hygiene, fisheries, agriculture, horticulture, forestry, and stock-raising. What may be called the general zoological sections of the book are often sketchy—as where the development of the Mammalia is dismissed in less than a page and the student is told that there is no placenta in marsupials. But there is much trustworthy information pleasantly given, the examples being drawn mostly from North American species. The concluding portion of the book is devoted to economic subjects, and there may be found accounts—good though brief—of harmful protozoa, insects, and arachnids, with the means to be adopted for repelling their attacks. The authors might perhaps have used the space at their disposal more effectively by expanding this section to fill the whole volume, leaving the student to get his general facts from existing books, of which there are surely enough. Yet a chapter of twelve pages on "Animal Life and Evolution" is a wonderful example of what can be done in the way of packing a surprising number of valuable facts and suggestions into a small compass. It might indeed be defined as a sample of "compressed biology." G. H. C.

## ECONOMIC GEOGRAPHY.

*An Atlas of Economic Geography.* By Dr. J. G. Bartholomew. With introduction by Prof. L. W. Lyde. Pp. lxvi+96 maps. (London: Oxford University Press, 1914.) Price 5*s.* net.

THE name of Bartholomew on any atlas is a synonym for careful draughtsmanship and artistic colouring, and the "Atlas of Economic Geography" is not only no exception to the rule, but also a marvel of cheapness. Prof. Lyde as joint-editor is responsible for the selection of the maps, which are intended to illustrate mainly world and continental distributions. So far as they go, the various maps and diagrams make up a valuable collection. The generalisation necessary for such small-scale maps has been on the whole successful, except in the case of gold, the colour for which is much too liberally distributed. No attempt has been made, however, to distin-

guish on the map of Europe between major and minor industrial areas, and the absence of large-scale economic maps of the countries of Europe distinctly handicaps the atlas for purposes of advanced study.

Prof. Lyde has also contributed an introduction, which contains a large amount of both information and speculation. The prefixing of a lengthy and highly didactic introduction to an atlas intended for general university use is a somewhat new departure from well-established precedent. The presence of such an introduction tends to embarrass the teacher, who in this case may possibly differ from Prof. Lyde both in matters of opinion and in methods of teaching. A brief description of the plates of an atlas may at times be useful, but the proper place for all controversial matter is in an accompanying handbook which need not necessarily be placed by the teacher in the hands of his students. An atlas should be concerned solely with facts, to the ultimate arbitrament of which a teacher may refer all matters of opinion.

There are two methods of teaching economic geography as a university subject. One is to make certain general statements, and then to proceed to illustrate them by reference to the distribution of certain commodities and industries. The other is to begin with the distribution, and after due consideration of all the facts to attempt a theoretical explanation. Since many of the so-called principles of economic and anthropo-geography are by no means demonstrated, the latter method would at present appear to be preferable. Prof. Lyde, however, evidently believes that better results may be obtained from the former. Hence his introduction abounds in picturesque and suggestive ideas which the student is encouraged to believe may be verified by a careful examination of the facts of production and distribution. For example, it is stated that the ideal climate for wheat is of the Mediterranean type, while as a matter of fact the maximum yield per acre, which, in the absence of any other universal criterion, may fairly be taken as an indication of climatic suitability, is found in a region the climate of which is not usually classified as Mediterranean.

Again, the climatic control of the distribution of textile industries, emphasised in the introduction, has long been one of the pious beliefs of economic geographers. It has now become customary to limit the application of this so-called principle to the manufacture of only the finest goods, but the necessity of introducing such a limitation should be sufficient to put teachers on their guard against making any categorical statement upon the subject. To state in advance and with authority the conclusion which should be drawn from a study of certain regional and economic facts is an insidious method of giving what may be an unfortunate bias to the undeveloped mind.

J. D. F.

## SEWAGE PROBLEMS.

*Sewage Purification and Disposal.* By G. B. Kershaw. Pp. x + 340. (Cambridge: At the University Press, 1915.) Price 12*s.* net.

THOSE who accept the conclusion of the author that "Sewage purification is the outcome of the activities of bacteria mainly, but assisted by chemical and physical actions, and the purifying agencies of various algæ and water plants," will probably consider that only in a limited degree does this book fulfil the claim of the editors of the series to present the latest scientific and practical information upon the subject with which it deals.

Consideration of the biological aspect of the problem is comparatively brief and superficial, and the author is of opinion that "It does not come within the province of this book to touch more than briefly upon chemical points." The outlook is that of an engineer, with extensive rather than intensive experience of the problem; the treatment descriptive and intelligently empirical rather than scientific, but within these limits the book is an informative account of present-day practice.

The difficulties, both quantitative and qualitative, of the sludge problem are kept well before the reader's attention, and it is realised that circumstances may justify the discharge of appreciable quantities of suspended matter on to suitably designed filters, with the view of effecting the separation of a large proportion of the inevitable solid matter in its least objectionable form. The entire failure to recognise the significance of the Dibdin slate bed, in this connection, is somewhat remarkable.

Probably the most useful sections of the book are those dealing with conservancy systems, and with land treatment, in both of which a clear conception of actualities is presented.

The references to foreign practice constitute a valuable feature, and in certain sections, as, for instance, those dealing with the influence of tank velocity upon the character of the deposit, either of detritus or of the main bulk of sludge, might with advantage have been extended, since English practice, as interpreted by the author (in dealing with the construction of detritus tanks, for example, "from 1/100th to 1/200th part of the total

dry weather flow of sewage is, perhaps, a usual capacity provided"), affords such uncertain guidance upon important details of works design.

Neither practical nor scientific value can be attached to Table XV, "Showing the dimensions of several septic tanks in use in England," or to the bald statement that circular tanks of the Dortmund type are in use, as septic tanks, in the absence of comment as to the suitability of the design to the object in view. The comparison between contact and percolating filters is carefully, and on the whole fairly, drawn, although it is not quite clear whether the working costs quoted are strictly comparable.

Assumption of the colloidal form is so characteristic a property of fæcal matter that the author's belief that the colloidal matter of sewage is derived in great measure from soap would seem to require some definite experimental support or reconsideration.

The book is well indexed, and is provided with a useful bibliography. PERCY GAUNT.

## THE PRODUCTION OF NEW VARIETIES OF PLANTS.

*Fundamentals of Plant-Breeding.* By Dr. J. M. Coulter. Pp. xiv + 347. (New York: D. Appleton and Co., 1914.) Price 6*s.* net.

PROF. COULTER is entering the ranks of the writers of books on scientific subjects, as he already has a place amongst those who produce scientific books. In the volume before us he has certainly achieved a considerable measure of success in making difficult matters fairly easy of comprehension by any ordinarily intelligent person. The carping critic may perhaps object that the dose of science is sometimes contained in too abundant a vehicle of padding, but at least he will scarcely allege that the padding itself is totally devoid of flavour.

The author has skimmed over many difficult and debatable matters with a freshness and vigour of expression which makes his book a pleasant one to read, and he has contrived to weave into the text a very considerable amount of theory and fact. Even those who are tolerably familiar with the work of plant breeding will probably find much that is of interest in what we might perhaps describe as the more remotely relevant matter. The book is, of course, written from the American viewpoint, but it is good that people in this country should have brought forcibly to their notice the supremely important problems that underlie so much of scientific agriculture, in which an immense amount of capital is invested. The Americans take these problems seriously, and the people are interested in the results which mean so much to the country, for it is from the soil and its living products that the permanent sources of wealth of a community must, after all, largely depend.

Prof. Coulter deals with the various methods of raising new and valuable plants, of conserving what has been obtained by the application of rational, and therefore truly scientific, principles which enable disease to be successfully fought, and by which further improvements are to be secured. He also deals with the more outlying topics of forestry, the soil, search for new plants, the work of experimental stations, and so on, and he may be congratulated on the production of an interesting, instructive, and readable volume.

We note a few points in connection with which a future edition will, perhaps, afford an occasion for modification. The lettering of the figures on p. 11 is omitted; and surely Figs. 15 and 16 should not be quoted from the text-book of which Prof. Coulter is joint-author, but from the original source, *i.e.* from Bonnier's admirable paper on the effects of habitat on plant structure. Exception might well be taken to the illustration on p. 5 of fluctuating and constant variation, on the ground that the potato tubers quoted are the result of vegetative, and not of sexual, reproduction, and the illustration itself also strikes one as having an air of unreality about it. A serious misapprehension of Weismann's position would probably be gathered by the uninstructed reader of p. 68, on which it is briefly stated that "Weismann thought that all the characters of both parents are represented by ids in the fertilised egg. This was the necessary antecedent to 'amphimixis.' Mendel, on the other hand, showed that characters are segregated in the reproductive cells." Weismann would certainly have repudiated the justice of the contrast in this form. But, despite slips such as these, the book is a good one.

## OUR BOOKSHELF.

*The Earth: Its Life and Death.* By Prof. A. Berget. Translated by E. W. Barlow. Pp. xi + 371. (New York and London: G. P. Putnam's Sons, 1915.) Price 7*s.* 6*d.* net.

PROF. BERGET has written in popular terms a physical history of the earth. He has endeavoured to discern the mode of its origin and to estimate its age, to describe the phenomena of the present living globe, and finally to forecast the manner of its death. He has certainly succeeded in rendering many difficult lines of reasoning clear and intelligible to the general reader. The book is in no part dull, and would not read like a translation were it not that English equivalents

are added after all measurements in metres or in centigrade degrees. Besides the translator's interpolations, an unnamed editor has inserted in the text many notes which would have appeared more appropriately at the foot of the page. As these notes are on astronomical points only, they leave the impression that other subjects stand in similar need of amendment, and there can be no doubt that this is the case in more than one chapter.

Sometimes the author writes with a little too much confidence. He treats a theory almost as if it were a scientific fact. For instance, he refers to the contraction theory of mountain-formation as though its foundation were secure. He accepts as proven an eleven-year period of earthquake-frequency and the increased frequency of earthquakes at the times of the equinoxes.

While reading the book, it is difficult to resist the impression that the author does not always trust to original authorities. This impression is perhaps strongest in the chapter on seismic phenomena, in which, though the original text must have been written in or after 1909 (see p. 208), many facts are omitted which should have found a place. Indeed, in this chapter of thirty-eight pages, the name and work of Milne are never once mentioned.

*A Map of the Western War Area.* Edited by Prof. A. J. Herbertson. 60 in. × 60 in. (Oxford: The Clarendon Press.) Price, mounted in sections, with names 15*s.*, without names 12*s.* 6*d.*

THIS useful and striking map depicts the country from the Seine to the Rhine, and from the Swiss frontier to the Rhine delta, on a scale of eight miles to 1 in. (1 : 500,000). It is provided with contour lines and layered colouring, and shows vividly the interdependence of land relief and military strategy. It is issued in several forms—unmounted, mounted in sections, and mounted on rollers, varnished or unvarnished, at prices varying from 10*s.* 6*d.* to 17*s.* 6*d.* Produced under the supervision of Prof. Herbertson, it provides an excellent and trustworthy companion for the student of current events in France.

## LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

### A Canadian Memorial to Hugh Miller.

IN a letter which I have just received from Dr. John M. Clarke, director of the State Museum at Albany, N.Y., he writes:—"You may be interested to know that at my urgent suggestion the Geographic Board of the Province of Quebec have adopted the name 'Hugh Miller Cliffs' for the wonderful Old Red Sandstone fish-beds which line Scaumenac Bay on the Bay Chaleur, near the Gulf of St. Lawrence. I think there is no place in the world where the fishes Hugh Miller described are so abundant. It is a little odd that the devout French Catholics of P. Quebec should consent to this naming of their scenery after a Scotch Presbyterian, but the cliffs look across the bay from French Quebec to Scotch New Brunswick!"

Geologists in this country will be pleased to hear of this Transatlantic recognition of Miller's pioneer work, and they will feel that Dr. Clarke, who is familiar with the classic Cromarty ground, as well as with that of Scaumenac Bay, deserves our thanks for suggesting this unusual but most appropriate memorial, and for his successful efforts to have it carried out. ARCH. GEIKIE.

Shepherds' Down, Haslemere, June 24.

### The "Green Fluorescence" of X-Ray Tubes.

THE Glass Research Committee of the Institute of Chemistry has recently issued a note on the conditions for obtaining green fluorescence under kathode rays in glass suitable for X-ray tubes indicating that the presence of a small amount of manganese must be present. In view of the fact that there appears to be some misconception regarding the necessity of the green fluorescence it may be of interest to give a brief account of what is involved in obtaining as marked a fluorescence as that which has usually been noticed in working X-ray tubes hitherto.

So far as I am aware the advantage of the green fluorescence is that it provides the X-ray operator with a convenient rough indication of the "hardness" of the tube. It is scarcely necessary to point out that the quality of the X-rays is in no way influenced by the nature of the fluorescence of the glass. Experiment has shown that a strong green fluorescence can only be obtained at some sacrifice of the excellence of the glass. Glass manufacturers frequently add manganese dioxide to a glass mixture to correct the green colour due to iron which is invariably present to some extent in the ingredients used, and, of course, the more iron there is as an impurity the more must be the amount of manganese dioxide added. Thus in some cases, in order to obtain the full green fluorescence, an appreciable quantity of iron must be added to relatively pure ingredients so that the necessary quantity of manganese may be incorporated in the glass, the iron being needed to correct the amethyst colour which so much manganese would otherwise impart to the glass.

This procedure appears to impair the working qualities of the glass to some extent, and it is found that glass of a quality superior (in respect to its behaviour in the flame) to that usually employed can be made if iron and manganese are avoided. A few experiments may be mentioned in support of this statement.

Glass made from pure materials shows practically no fluorescence, the feeble glow being of a grey-blue colour. A Rupert's drop made from the same glass gives a similar feeble glow.

A Rupert's drop made from glass giving normally a strong green fluorescence shows only a slight grey-blue glow. After the tail of the drop had been heated to softening point this part showed the usual green glow. In a high vacuum under very intense bombardment there was an indication of some slight green glow on the drop. The drop was broken and the powdered glass gave the full green glow. The evidence was that only a very thin skin represented the part cooled quickly enough to give next to no fluorescence.

Calcium silicates of varying composition containing a little manganese, which were fused by the oxy-hydrogen blowpipe, showed on the outside portions, which appeared to be completely vitreous, no

fluorescence at all, while the inside which had cooled more slowly, and was found to be crystalline, gave a very brilliant green glow.

Calcium metaborate can by very sudden cooling be obtained in a vitreous state showing no fluorescence, while the crystalline variety gives a moderate blue glow. The presence of manganese induces no fluorescence in the vitreous form, but a very brilliant green in the crystalline modification. Evidence has been obtained that many substances which, in their crystalline form, fluoresce brightly, exhibit no glow in the amorphous or vitreous state.

From numerous experiments it is concluded that the green fluorescence of X-ray tubes is associated with the presence of a notable quantity of calcium and a relatively small amount of manganese, that a truly vitreous glass exhibits little, if any, fluorescence, and that a glass containing manganese can only be kept in this condition by extremely sudden cooling.

Without suggesting that ordinary X-ray glass has any definitely crystalline structure, the evidence would indicate that something akin to this is more readily obtained when manganese is present.

A tendency to crystallisation may be so slight in a glass as not to interfere with its use under ordinary working conditions, but there is no advantage in fostering this tendency. The presence of manganese in any appreciable amount introduces other defects of minor importance. I mention them only to emphasise the point made before, that if the intensity of green fluorescence seen in many foreign X-ray tubes is considered imperative it can only be obtained by sacrificing some of the good working qualities of the new and purer English glass.

HERBERT JACKSON.

University of London, King's College, June 23.

### The Magnetic Storm and Solar Disturbance of June 17, 1915.

THE magnetic storm described in NATURE of June 24 by the Rev. A. L. Cortie seems to have been larger at Stonyhurst than at Kew. The extreme westerly position of the declination needle at Kew occurred about 1.30 p.m., and the extreme easterly position about 5.37 p.m., the total range being about 72′. Between 5 and 6 p.m. the movements had a range of 61′. I am not clear which of the two corresponds to the 91·5′ mentioned by Father Cortie, but either is substantially less, even allowing for the fact that the strength of the horizontal field is about 6 per cent. higher at Kew than at Stonyhurst. This is, of course, quite in accordance with the usual tendency for disturbance to be greater in higher latitudes, but it helps to illustrate the fact that whatever the ultimate source may be, terrestrial position counts for a good deal. The total range shown by the horizontal force at Kew was about 460γ ($1\gamma \equiv 1 \times 10^{-5}$ C.G.S.), the maximum occurring about 5.42 p.m., and the minimum about 9.30 a.m.

Father Cortie's remarks on the absence of the rapid oscillations sometimes characteristic of magnetic storms refer, I presume, to the time 4 to 6 p.m., when the largest movements occurred. Earlier in the day, for instance, near 6 a.m., the oscillatory character was fairly prominent at Kew. One would, in fact, have expected to hear of telegraphic interruptions.

Father Cortie seems to associate the magnetic storm with a particular spot or group of spots on the sun. That at least is what one would naturally infer from his remark: "Such a close approximation of the position of the spot and the earth referred to the sun's central meridian during a magnetic storm is very unusual." Whether magnetic storms are directly due to the emission of electrons from the sun, and, if so, whether the emission is localised in sun-spots, are questions on which there is a diversity of opinion. The present case seems a good example of the difficulties in the way of a final decision. Father Cortie tells us that "on June 17–18 there were no fewer than seven groups of spots visible." On the other hand, the disturbance of June 17, though much the largest, was by no means the only magnetic disturbance about the time. There was, as Father Cortie mentions, what is usually termed a "sudden commencement" about 1.50 a.m.—I make it a minute or two later—on June 17, but there was another—somewhat larger—about 1 p.m. on June 16. The subsequent disturbance on June 16 was not large, and after 6 p.m. the conditions were fairly normal. We should naturally regard the disturbances on June 16 and 17 as distinct. Then on June 21, about 3.10 p.m., there was yet another "sudden commencement," the largest of the three, and this was followed by a considerable disturbance lasting to the end of June 22. "Sudden commencements," even when small, are usually recognisable over at least the greater part of the world. Of all types of disturbance they seem to have the best claim to a cosmic origin. The subsequent disturbances, when there are any worth mentioning—which is not always the case—show much more rapid local variation.

We have here, then, three disturbances with sudden commencements in the course of about five days, so that even accepting the sun-spot emission theory, in the absence of special identification marks, the association of one particular disturbance with one particular spot or group of spots would seem to be arbitrary.

Another aspect of the case is that magnetic disturbances sometimes occur when sun-spots are conspicuously few or wholly absent. For instance, there was a "sudden commencement" of considerable size on June 7, at a time when Father Cortie tells us the sun was almost free of spots.

The fact that magnetic disturbances occur at intervals of from twenty-six to twenty-eight days more frequently than is accountable for by pure chance is obviously consistent with the sun-spot emission theory; but it does not necessarily favour it. Quiet magnetic conditions show the "twenty-seven-day" period to practically the same extent as disturbed conditions. Sometimes disturbance is the rule, and quiet conditions the exception, and it is not clear that the one phenomenon is more fundamental than the other. There seems a difficulty in associating quiet conditions with some limited area, some "anti-spot," on the sun.

C. CHREE.

June 26.

### The Names of Physical Units.

MAY I point out that Dr. Guillaume is wrong in suggesting, in his letter in NATURE of June 17, that the adjective "specific," employed in connection with physical magnitudes, has no constant and definite meaning? "Specific" is the adjective of "species," and the "specific resistance of iron" is that function of the resistance of a piece of iron and the other physical magnitudes characteristic of the piece which is the same for all pieces which belong to the species "iron." The statement made in the last sentence is true if for "resistance" be substituted any other magnitude to which "specific" is attached, and for "iron" any other form of matter which is recognised as a "species."

I am not urging that the retention of the term "specific" is desirable; on that matter I offer no opinion. I am only urging that the word has a perfectly definite and constant meaning.

Teddington, June 22. NORMAN R. CAMPBELL.

## THE USE OF COTTON FOR THE PRODUCTION OF EXPLOSIVES.

THE history of the laboratory production of various forms of nitro-cellulose has been well stated by many chemists, and everything essential can be found either in their own researches or in the ordinary text-books. The practical outcome of such work has been the establishment of modes of manufacture for many purposes, but in the present instance it is proposed to deal entirely with the use of cellulose in one shape or another for explosives of any practicable kind. It is almost unnecessary to state here that every kind of propulsive explosive now used has cellulose as its basis, but it may not be superfluous to say that all military propulsive explosives have cotton for their basis as distinct from cellulose.

The word cellulose must not be understood in the strict chemical sense, but rather as including all those materials which are chiefly cellulose, and this definition will include materials like wood-pulp. Now one may clear the ground on this subject at once by saying that, for military purposes, wood-pulp and other impure forms of cellulose are useless. Very good sporting powder can be made from nitrated wood-pulp, but the artillerist would be in great difficulty if he were provided with such a propellant, because in order to obtain any sort of regularity the nitration of the wood-pulp has to be kept at a low point, and the ballistics on which the artillerist depends would be quite thrown out. The modern gun is really a machine of precision; the artillerist knows that and expects it to throw one shot after another to reach the same point within a fraction of its possible range as computed from its elevation of sighting, and his whole attention has been based on this. If he were supplied with a material, however good, which on explosion developed a lower pressure, he would be relatively helpless and his rivals, using their own standard material, would have him at a sore disadvantage.

In modern practice, the raw material used is cotton waste, which is, as its name implies, merely the rejected stuff in the manufacture of cotton goods; and although linters, which is the technical term for the short fibre material adhering to the cotton seed, may be used, yet its employment presents serious difficulties in that the seed with which it is associated has to be removed by chemical treatment. There have been many experiments made to use such substances as jute, ramie, kapok fibre, and in short everything from sulphite pulp to spun cotton, but as workable substances these have been rejected in favour of the staple material—cotton waste.

The method of producing a satisfactory form of nitro-cellulose from cotton waste is as follows:—The waste is hand-picked so as to remove the grosser impurities. The product is teased, picked once more, and then dried. After that, the nitration process is carried out, and this has been much modified in the light of experience, but in essence still consists in the immersion of the purified waste in a mixture of nitric and sulphuric acids of the following composition: $H_2SO_4$, 71 per cent.; $HNO_3$, 21 per cent.; $H_2O$, 8 per cent. The amount of water in this mixture is important, and the acids as they are written are as their formulæ represent and do not refer to the commercial products. The strict relationship of the water to the two active materials should be preserved. It is of course easy now to obtain sulphuric anhydride ($SO_3$) and make an anhydrous mixture, but this gives a nitro-cellulose with too high a nitrogen content. After the mixed acids have acted for the required time, they are removed and the gun-cotton is washed to remove as much of the acid as possible, and purified by several boilings with water. The boiling with water is of great importance, as in this part of the process the unstable bodies produced during nitration are dissolved or decomposed, leaving the nitro-cellulose in a stable condition. The only thing now remaining is to pulp the cotton, which is again washed and then partly dried and moulded into the required shape by pressure.

The old idea that something as nearly as possible to the so-called hexa-nitrate of cellulose should be aimed at has been fairly well exploded, and the manufacturer seeks to regularise his output so that he may obtain a nitro-cellulose with approximately 11 molecules of $NO_3$ to the quadruple molecule, as shown in the formula $C_{24}H_{29}O_9(NO_3)_{11}$. This formula must not, however, be taken as any more than a convenient way of expressing the degree of nitration, which is really better stated in terms of content of nitrogen which ranges between 12·93 and 13·05. This is merely a parenthesis, but is necessary as showing how delicate and complicated a matter it is to obtain a uniform and trustworthy material for propulsive explosives, and as it has been found in practice that even what is apparently such a simple matter as the preparation of a mixture of acids of known composition is really one requiring some care and skill. It will be readily understood that the difficulty is trifling compared with that of providing an equally regular form of cellulose. So well is this recognised that different consignments of cotton waste, all of approved quality, all picked, teased and re-picked, are mixed so that the cellulosic raw material may be as nearly the same grade as possible.

With this fact in front of us, let us consider what the condition of a factory would be which had to use any kind of raw material, clean or dirty, lignified or not, and had to try to make that into a trustworthy propulsive explosive of standard quality. This question has only to be asked for the answer to provide itself. In the present case a great deal too much has been assumed as to the capability of our enemies for making trustworthy nitro-cellulose without cotton waste. Because any competent chemist in his laboratory could make some form of nitro-cellulose from his own shirt cuffs if he pleases, people have jumped to the conclusion that that will be of some use

to the artillerist. The fact that the manufacturing process of an explosive like this is of the most delicate kind and has to be conducted with military precision, has been constantly overlooked; and at the present moment it is not too much to say that there is only one material available for modern gunnery, and that is cotton.

## *PROBLEMS OF AIRSHIP DESIGN AND CONSTRUCTION.*

THE problem of the airship falls naturally into three parts, concerned with flotation, propulsion and steering respectively. The best results in any of these three branches are to a great extent antagonistic to similar success in one or both of the other two. For instance, flotation, which is purely a displacement problem at bottom, demands that the displacement body should have the greatest volume for the least superficies, *i.e.*, that it should be spherical. Propulsion, on the other hand, demands that the body be of the shape having least head-resistance, *i.e.*, of long fish-shape. Steering, with which is linked dynamic stability, demands that large fins and control surfaces be affixed to the body, which otherwise would set itself broadside on to the relative current caused by its forward movement. These auxiliary surfaces add to the weight, that is, oppose flotation and add to the head-resistance, thus opposing propulsion. Again, the displacement body must of necessity consist mainly of a gas lighter than air. All the light gases are highly inflammable (or if not have some other disadvantage), and consequently are dangerous in proximity to an internal-combustion motor, such as is universally used for propulsion, as being the only motor with a good ratio of power to weight. Therefore the motor must not be placed too close to the gas-container, and in consequence it is difficult to enclose all the parts of the airship in a single "streamline" body of least resistance, and the head-resistance and weight are thus both increased considerably, opposing propulsion and flotation.

The above list of incompatibilities might be extended considerably, as every airship designer knows to his cost. It is not to be wondered at, therefore, that airship design is in so fluid and embryo a condition that the future of the airship is looked upon as extremely dubious in many quarters. The fact, however, that so much progress has been made in face of stupendous difficulties is a happy augury for the future of the airship, especially as many of the difficulties met with are due mainly to the fact that airships are at present small, and they will disappear as soon as experience and growing confidence enable large and larger vessels to be built.

To deal with the displacement body, or lifting unit, first. The lift obtainable is, of course, directly proportional to the weight of air displaced and inversely proportional to the weight of the displacement body in itself. Roughly, thirteen cubic feet of air at sea-level and normal temperature weigh one pound, so that a lifting unit displacing that volume would lift one pound minus its own weight. Consequently, if the lifting unit consisted of "nothing shut up in a box" as the schoolboy's definition of a vacuum runs, only the weight of the box would have to be deducted from the gross lift obtainable. As no light vacuum-container could maintain its shape against atmospheric pressure, however, a gas must be used to keep the displacement body distended by its expansive properties. The gas universally used for airships is hydrogen. This weighs about one-fifteenth of unit volume of air, so that only 1/15 gross lift is lost by its use. The possibilities of getting wonderfully enhanced lift by new gases, lighter than hydrogen, are thus seen to be illusory.

Coal gas was long used (and still is) for ordinary spherical balloons, as being cheaper and more available than hydrogen, but being about ten times as heavy as hydrogen, is comparatively useless for airships. Ammonia vapour has been suggested for airships, as being non-inflammable, but is about eight times as heavy as hydrogen and of a destructive character to metal, etc. The provision of a stable non-inflammable light gaseous mixture would solve so many practical difficulties in the construction of airships that many thousands of pounds could profitably be expended in research on this problem. Failing this provision, all precautions must be taken to prevent fire, or to minimise its effects on board airships.

Hydrogen being non-explosive apart from oxygen, can be isolated in containers jacketed with an inert gas and thus rendered harmless. The division of the displacement body of an airship into compartments is desirable from this and other points of view. For example, a large volume of gas in a thin fabric container is prone to surge about and strain the container when in motion. Compartments prevent this and also localise leakage due to rupture of any part of the container.

The type of airship in which this principle is carried farthest is the rigid type (Zeppelin) in which the displacement body consists of seventeen or eighteen separate gas-containers, set in a rigid cylindrical framework, like peas in a pod. The chief advantages of the rigid framework are (i) that the actual gas-containers are relieved of strain and are (ii) protected from the influence of weather. The disadvantages are (i) the loss of gross lift due to the weight of the framework, and (ii) the fact that the airship cannot be folded up for transport or storage, and must consequently be housed in a large and expensive shed.

The gross lift of a large Zeppelin is about twenty-five tons, of which about twenty tons are absorbed by the framework, engines, etc. This gives a net lift of only about one-fifth of the gross lift, a figure that could be much improved upon by making the vessel larger. This net lift has to account for crew, etc., so that not more

than two tons of explosives could be carried, and this only at a low altitude. Naturally, other things being equal, the weight of the framework, etc., of a small airship is a larger proportion of the gross lift than the corresponding weight of a large airship.

In that type of airship in which the walls of the gas-container are themselves the "framework" of the displacement body (the "non-rigid" type), much weight is saved, but disadvantages come in that strains on the fabric affect its gas-tightness, which is also much affected by action of sun and other influences.

Again, the attachment of the car (containing the engines, etc.) by wire ropes to the container is worked out on the assumption that the gas-container will retain its shape. This end is attained in single gas-containers by having a bag of air (the "ballonet") inside the container, into which is pumped air under pressure, to maintain the full volume and shape of the envelope. If, however, compartments are to be used in the container, some means of equalising their pressures even if one be ruptured must be devised, otherwise the shape will be distorted. This is no easy task.

The non-rigid type has the great advantage of being quickly deflatable for transport packed up. Examples of this type are the Parseval and Astra-Torres, in which latter ship an ingenious system of suspension greatly strengthens the gas-container.

The "semi-rigid" type has some of the advantages and the disadvantages of both the other types. Examples are the Forlanini (Italian) and Astra XIII. (Russian).

The material of which gas-containers are usually constructed is made of layers of cotton fabric cemented to layers of rubber. In order to intercept the blue (actinic) rays of light that "rot" the rubber very quickly and make it porous to the gas, the fabric is coloured yellow. Goldbeater's skin makes a very gas-tight container, but untreated is affected by rain, which is absorbed, and by its weight decreases the net lift. This disadvantage applies to untreated fabrics, which are therefore usually varnished with an aluminium varnish, thus preventing water absorption and promoting gas-tightness. Fabric impregnated with gelatine, rendered flexible by added glycerine, and insoluble by formaldehyde, has given promising results. Oiled silk is very gas-tight but seams are troublesome. Very much research is still required into the question of fabrics.

Propulsion demands a power plant and means for obtaining a reaction from the air. The ratio of power installed to weight lifted has been steadily rising both in airships and aeroplanes. The first Zeppelin airship (1900) weighed 10,200 kilograms and the motors were two, totalling 32 horse-power. Zeppelin III. (1906) lifted 12,575 kg., and the motors (2) totalled 130 effective h.p. The "L1" (marine) of 1913 lifted about 28,000 kg., and the motors totalled 720 h.p. As an indication of the performances that may be expected from airships in years to come, we may note the proportion of power to weight lifted in the last vessel as one horse-power to every 80 lb. lifted. The speed attained is fifty miles an hour. In the case of an aeroplane doing ninety miles an hour or so, the weight lifted is only about 15 lb. per horse-power.

Screw propellers are universally used for airships, and are often of wood. They are usually placed at the sides of the gas-container in rigid vessels and below it in non-rigid vessels. Much research is needed as to the best position for propellers relatively to the body to which they are attached.

A strong reason for increasing the power of airships is that by so doing a large amount of lift can be obtained by the dynamic action of the large control surfaces, which, by directing the airship's nose up, are able to give it a very fast rate of rise, much quicker than that of aeroplanes.

The maximum height attained by airships is somewhat more than 10,000 feet (Zeppelin and Italian). Aeroplanes have ascended twice as high and ordinary balloons three times as high. To attain 10,000 feet high an airship must sacrifice much ballast and gas, so that it cannot voyage for its longest period at a great height. Zeppelins are claimed to be capable of holding the air for three days, but not at full speed or height. There is no advantage in going very high (except for military reasons), and under 3000 feet would be a usual zone in which to operate were it not for anti-aircraft measures. Some day, when the airship is better developed, it may pay to go to great heights in order to obtain the advantage of lessened resistance to advancement due to the tenuity of the air.

As regards steering and stability, it may be said at once that most airships steer clumsily and require large spaces in which to manœuvre. Our little non-rigid vessels have been specially developed for handiness in our much wooded country, but Zeppelins are craft for vast open spaces. The dynamic stability of an airship is a complicated matter to work out. Besides ordinary pitching and rolling there are added effects due to surging of the gas and distortion of the gas-container. Propellers also complicate the stability question. Large control surfaces are essential, sticking well out from the body, to avoid its "wash."

## *A REGIONAL SURVEY.*[1]

A MODERN element in the fascination that islands undoubtedly exert is their biological interest. What are the island's inhabitants of high and low degree? How came they there and whence? How has the isolation affected them?

1 "A Biological Survey of Clare Island in the County of Mayo, Ireland, and of the Adjoining District." Section I. (comprising Parts 1 to 16), Introduction, Archæology, Irish Names, Agriculture, Climatology, Geology, Botany. Section II. (comprising Parts 17 to 47). Zoology (Vertebrata, Mollusca, Arthropoda, Polychæta). Section III. (comprising Parts 48 to 68), Zoology (Oligochæta to Protozoa), Marine Ecology, Summary. (Dublin: Hodges, Figgis, and Co., Ltd.; London: Williams and Norgate, 1911–15.)

Such are the biological questions which, as Mr. Lloyd Praeger remarks, have led many naturalists to study islands. He recalls Alphonse de Candolle, Edward Forbes, Charles Darwin, Alfred Russel Wallace, and Sir J. D. Hooker; and many other names might be cited. The same old questions led a number of naturalists in 1909 to plan and inaugurate the survey of Clare Island, which has now been completed to the great credit of all concerned. The island was chosen because of its suitable size and position, because of its unusual elevation as compared with most of the islands lying off the west coast of Ireland, and for various practical reasons.

Clare Island lies across the entrance to Clew Bay, at about the middle of the great projecting buttress of ancient rocks which forms west Galway and west Mayo. It is almost cliff-bound, the cliffs varying from 50–100 ft. in the east and south to 1000 ft. in the north-west. The dominating feature is the high ridge of Croaghmore (1520 ft.) on the north-western shore. "On the inland (southern) side Croaghmore presents a steep heathery slope, and on the seaward face plunges down a magnificent precipice into the Atlantic." Its scarp is the home of a very interesting Alpine flora, and affords a sanctuary of wildness to many animals which could not survive the close grazing of other parts of the island. The adjoining islands of Inishturk and Inishbofin, which are included in the survey, are in a general way similar to Clare Island, but with no such lofty elevations.

The survey had two main objects in view:—(1) The study of the fauna and flora of this extreme verge of the European continent, and (2) the study of an insular area with reference to the special problems of island life and of the dispersal of organisms. As regards the first object, the results have far exceeded expectations, but as regards the second there was some disappointment.

A geological study of the area showed that it was not only probable, but almost certain, that a land-connection between the island and the mainland existed long after the Glacial period, which would have permitted of the immigration of much of the present fauna and flora after normal climatic conditions were resumed.

In short, the investigators soon found that they had to do with an assemblage of animals and plants that had *not* crossed even a few miles of sea.

As regards the fauna and flora in general, excluding winged animals and spore-plants, there is practical unanimity of opinion, resting on varied evidence from many different groups, that the narrow strait of sea which separates Clare Island from the mainland represents a very serious barrier to migration, and one across which the existing fauna and flora of the island, taken as a whole, could not have passed.

If the study of Clare Island as an island was rather negative, the other aim of the survey was realised in a manner positive enough to delight everyone, and some indication must be given of the number of additions made to the fauna and flora of Ireland and of the British Isles, and of the number of species discovered which were new to science. No fewer than 3219 plants were recorded, of which 585 were new to Ireland, fifty-five new to the British Isles, and eleven new to science. No fewer than 5269 animals were recorded, of which 1253 were new to Ireland, 343 new to the British Isles, and 109 new to science. This is a very gratifying result, and shows how many new forms of life still lie to be discovered not very far from our doors. It is pleasant to read that "almost the whole survey was carried out by volunteers, whose field-work had to be done in their own time, and, to a great extent, with their own money."

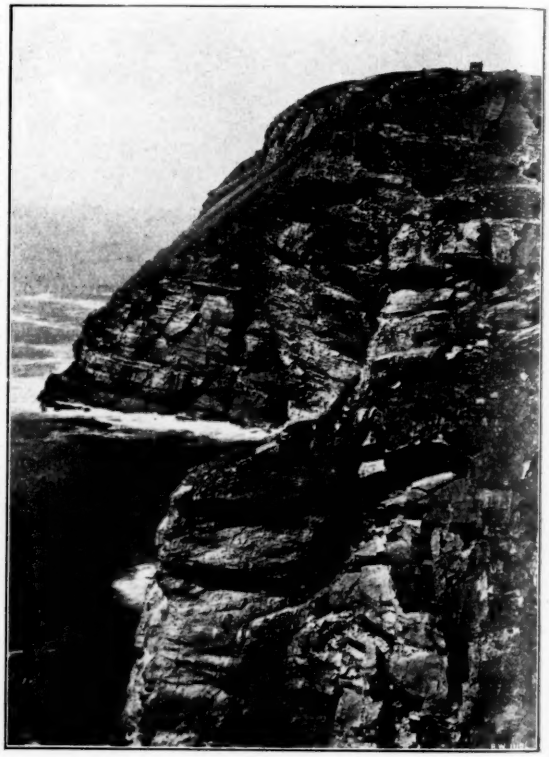

*Photo.*] [*R. Welch.*

FIG. 1.—Signal Tower Head, Clare Island. Silurian cliffs, 700 ft. high. Looking north. From "Clare Island Survey."

There are sixty-eight reports altogether, so that it would take considerable space even to mention subjects and authors. We are tempted to remark on the Foraminifera dealt with by Messrs. Heron-Allen and Earland (recording 287 species, thirteen new); on the Rhizopods by Messrs. Wailes and Penard (recording 129 species, five new); on the Flagellates and Ciliates dealt with by Mr. Dunkerly (recording ninety-eight species, many of them very interesting forms); on the marine sponges described by Miss Stephens (sixty-five species, including the new and interest-

ing *Leucandra cliarensis*, with dermal monaxon spicules visible to the naked eye and giving the sponge a characteristic silvery-white appearance; on the Turbellarians reported on by Mr. Southern (forty-five from the sea and five from fresh water); on the Polychætes tackled by the same energetic worker (249 species, sixteen new—by far the largest list as yet recorded from any limited area); on the new genus Grania discovered by Mr. Southern, the first Oligochæt found beyond low-water mark and occurring down as far as twenty-four fathoms; on the spiders recorded by Mr. Denis R. Pack-Beresford (108 species and ten Phalangids besides); on the fresh-water mites dealt with by Mr. Halbert (eighty species, four new)—but it is obvious that we must not continue. It is needless to pick and choose where all the workmanship is good. Some of the studies—notably on Marine Algæ, Phanerogams, Polychæts, and Foraminifera—are much more complete than others, and this, it should be noted, is in part due to the simple fact that some of the specialists were able to visit the island oftener than others. This readily intelligible inequality was, of course, to some extent counteracted by co-operation in collecting.

*Photo.*] [*G. P. Farran.*

FIG. 2.—Clare Island from E.N.E. Croaghmore in the centre. Lighthouse on extreme right. Harbour on extreme left. From "Clare Island Survey."

Looking into the novelties more analytically, we find fifteen new genera—one among Fungi, three among Mites, three among Chætopods, and eight among Nematodes. As to the last, it must be borne in mind that our knowledge of British free-living Nematodes has been of the scantiest, and we are not surprised that Mr. Southern should speak of one of the gatherings as furnishing "an apparently inexhaustible source of new and interesting species." It was among the Lower Invertebrates and Lower Cryptogams that the biggest hauls of new records and new species were obtained. Thus there were thirty-three water-bears recorded, all new to Ireland (for there had been no water-bear list before), eleven new to the British Isles, and five new to science. One of the most interesting results is the demonstration of the rich micro-fauna of the "Polygordius ground"—a sub-littoral habitat with gravel, sand, and broken shells lying in about twenty-five fathoms of water. It abounds in the primitive Annelid Polygordius, and yielded six new genera and twenty-eight new species of small fry.

We should like to have been able to refer to the discussion of marine ecology by Mr. Southern, to the admirable introduction, narrative, and summary by Mr. Lloyd Praeger, and to the reports on history and archæology, place names and family names, Gaelic names for plants and animals, agriculture, climate, geology, tree-growth (rather a negative quantity), and non-flowering plants; for this model regional survey has been as comprehensive in its scope as it has been thorough in its treatment. The survey has been completed in six years, which means hard work and loyal co-operation. We heartily congratulate those who have contributed to an achievement to be proud of, and most of all the secretary and editor, Mr. Lloyd Praeger.

## *PROF. BARNARD'S ASTRONOMICAL PHOTOGRAPHS.*[1]

THE name of Barnard is not only familiar to all astronomers, but also very generally to those who have from time to time perused illustrated astronomical books. The photographic recording of celestial objects has been carried by him to a very high state of perfection, and thereby not only has his own fame and that of the Lick Observatory been considerably enhanced, but our knowledge of the visible and invisible universe has been greatly extended. Unfortunately, it is an extremely difficult matter to reproduce, with complete accuracy, such photographs as are obtained by the combination of a telescope and a photographic plate, for not only do delicate lights and shades become relatively altered, but other errors may and do creep in during the process of reproduction. Further, the attempt to secure such high accuracy in reproduction increases very considerably the cost of publication. It will be gathered, therefore, that the extreme fineness and beauty of the original pictures cannot necessarily be judged by plates that have so far been published.

It is a great pleasure now to record the fact that, by a generous response for financial aid and with the assistance of considerable skill in reproduction, Prof. Barnard has been able to publish a selection of the photographs he took during the years 1892 to 1895. The volume contains 129 plates reproduced by the collotype process, and

1 "Photographs of the Milky Way and of Comets, made with the Six-inch Willard Lens and Crocker Telescope during the Years 1892 to 1895." By E. E. Barnard, Astronomer in the Lick Observatory, University of California. Publications of the Lick Observatory, vol. xi., 1913.

while Prof. Barnard states that "the very great delay in the appearance of this volume of photographs can only be attributed to the writer's anxiety to secure the best possible reproductions of the original pictures," the excellence of the reproductions is the reward due to the delay in question.

In the introduction to the volume the author brings together some very interesting information, both instrumental and photographic, with regard to these pioneer days. Possibly for the first time a statement is made regarding the origin of the now famous 6-in. "Willard" lens, the lens so often coupled with Barnard's name in celestial photography. Willard, so far as the author could gather, was not a maker of lenses, but simply a photographic stock-dealer, whose name was stamped on lenses made by C. F. Usner in New York City. These large lenses were used for making portraits during the wet-plate period of photography, their large apertures being necessary to shorten the exposure during portrait sittings. Their application to astronomical work was first made by an amateur who used the above mentioned 6-in. "Willard" lens for photographing the solar corona during the eclipse in January 1, 1889, visible in Northern California. Some of the photographs taken were so excellent, and showed so well the great extent of the coronal streamers, that Prof. Holden, then director of the Lick Observatory, who was impressed with the excellent results obtained with it, purchased this lens for the observatory with funds provided by the Hon. C. F. Crocker.

Prof. Barnard came to use it in the following manner:—

> I had been endeavouring to photograph the star clouds of the Milky Way with a small Voigtländer rectilinear lens attached to the 6-in. equatorial, but because of the slowness of the lens, had secured but feeble impressions of these clouds. The great light ratio of the old 6-in. lens suggested that it would perhaps serve my purpose. The results of some experiments which I made with it in photographing the Milky Way were very beautiful and intensely interesting. When the importance of the lens for such astronomical work became apparent, Prof. Holden placed it in the hands of Brashear, who refigured it and greatly improved the definition of the star images.

Prof. Barnard gives the dimensions of the lens, and as these are of interest they may be mentioned here:—

Diam. of front lens 5·85 in. = 148·6 mm.
„ back „ 6·73 „ 171·0 „
Solar focus 42·59 in. = 108·2 cm.
„ „ 70·2 „ 178·3 „

The distance from the rear surface of the front lens to the surface of the back lens was 12·8 in. A diaphragm of 3·83 in. aperture was placed between the two sets of lenses at a distance of 5·54 in. from the front lens.

The early photographs of the Milky Way and comets were first made with the "Willard" lens in a wooden box camera strapped on to the 6½-in. equatorial, the last-mentioned being used as a guiding telescope. Afterwards the lens, in its wooden box, was fixed on an equatorial mounting made by Brashear, the gift of the Hon. C. F. Crocker, and the telescope named after this donor.

The frontispiece shows the instrument with the 6-in. lens mounted, and also the Crocker dome which contains it.

It should be mentioned here that the new mounting was not equipped with a finder, so Prof. Barnard had to make use of the only telescope which was available for the purpose. This consisted of a small telescope, having only an aperture of 2·4 in., and there was no arrangement for the illumination of the cross threads, so desirable for very dark nights. Prof. Barnard had therefore to employ iron wires sufficiently coarse to be just visible in black relief on the dark sky. By racking out the eyepiece until the star was a little out of focus, he thus formed a disc, which he adjusted not only to be exactly behind the point of intersection of the wires, but of such a diameter that it was eclipsed by the wires with the exception of four small portions which peeped out of the four quadrants; for "following" purposes, these four positions were kept perfectly equal, the slightest inequality being detected and corrected at once. Anyone who has used this method knows how efficient it is, provided the star used for following is sufficiently bright; but, as Prof. Barnard points out, for "following" on a comet which has not a bright nucleus, "the following becomes a serious question, subject to considerable uncertainty, especially if the comet is faint." This drawback accounts, as he remarks, for the ragged condition of the trails of Brook's comet in his photographs. In spite, however, of the inefficiency of the following telescope, Prof. Barnard by his skill achieved wonderful results.

Turning now to the photographs, the page facing each plate is devoted to details of the photograph, such as date, exposure, scale, identification of stars, &c., and a brief description of the principal features. In cases where certain plates call for a more detailed description, further information is placed in the main text.

Thus, for instance, the region of the great nebula of $\rho$ Ophiuchi is so treated. In the description of this plate Prof. Barnard says: "I do not think there is any other region of the heavens so extraordinary as this. . . . One hesitates at any attempt to describe it. Perhaps even more remarkable than the nebulosities are the vacant lanes that run eastward from the great nebula and those in the upper part of the plate." These lanes, as Prof. Barnard has previously published, suggest strong indications of light obscuration by interposing nebulous or other matter in space. This remarkable region is one of many which were discovered by him with the Willard lens. The nebula of $\nu$ Scorpii is pointed out as being of far greater interest in the direct evidence it gives of the obscuration of light in space.

Plate 3, showing the region of the great nebula of Andromeda, gives an example of the difficulty

of accurately reproducing plates from the original negative. Prof. Barnard is in every case very careful to point out the defects in each reproduction, for sometimes some inequalities of illumination, looking like nebulosities, are really defects of reproduction, even in these plates after so much care has been taken. The nebulous region of 15 Monocerotis is a wonderful photograph, and the reproduction is described as "beautiful." It shows most distinctly the great nearly vacant region beginning near the nebula and running for two or three degrees to the west and then turning north for even a greater distance. The plate illustrating the small star cloud and black holes in Sagittarius is one of numerous other fine specimens of Prof. Barnard's skill, but of which space forbids one to more than mention. No less beautiful than the Milky Way photographs are those showing comets. Among the many illustrated, most instructive are the changes of the forms of Comet I. 1892 (Swift), Comet IV. 1893 (Brooks), and Comet II. 1894 (Gale), series of photographs of which are given. Plate 101 records an interesting picture displaying the trail of the first comet (Comet V. 1892) discovered by the aid of photography.

While Prof. Barnard has brought still more to perfection his collection of astronomical photographs by using lenses more effective than the old "Willard" lens, yet this record of pioneer work is one to be thoroughly proud of, and astronomical literature is greatly enriched by the permanent record contained in this fine volume.

WILLIAM J. S. LOCKYER.

## *CEREBRO-SPINAL FEVER.*

CEREBRO-SPINAL fever is a disease which occurs sporadically, *i.e.*, as occasional isolated cases, or in epidemic form The first authenticated epidemic seems to have been in Geneva in 1805. In 1806 it appeared in the United States, and continued to prevail there for ten years, and again in 1861 to 1864. During this period, and indeed throughout the first half of last century, it was observed in different towns of France and of Italy, in Algeria, Spain, Denmark, etc. In 1854 and for seven years afterwards it raged in Sweden, destroying more than 4000 persons in that country. In 1863 it broke out in Germany and spread from north-eastern Prussia to the south German towns. In 1846 it appeared in many of the workhouses in Ireland, and in 1866–68 a very fatal type of it prevailed in Dublin, and to some extent in other parts of the country. The disease never seems to have established itself in London, or indeed in England, but during the last ten years epidemics of some severity have prevailed in Belfast, Glasgow, and Edinburgh, and during the past year a number of cases have occurred in different parts of the country, particularly in connection with military camps.

Cerebro-spinal fever is also termed *epidemic meningitis*, or *epidemic cerebro-spinal meningitis*, from the fact that the prominent lesion is inflammation of the membranes (meninges) of the brain and spinal-cord. Another name is *spotted fever*, owing to the occurrence of an eruption of hæmorrhagic spots, particularly on the abdomen, which, however, is often absent.

The incubation period varies, but is frequently not more than four or five days, and the onset of the disease is usually sudden and ushered in by headache and vomiting. Stiffness and pain in the neck and retraction of the head are frequent, and twitching of the limbs and muscular tremor are often observed. Mental enfeeblement, stupor, or insensibility may occur, fever is present with prostration and wasting, and weakness or paralysis of various groups of muscles may ensue.

Cases show considerable variation in severity and duration; some are acute, others chronic, some are mild, others severe, and others again very acute and fulminating, so that death may result within twenty-four hours of the onset.

The causative micro-organism is a micrococcus, the "meningococcus" (*Diplococcus intracellularis*), a small spherical microbe measuring about 1/25,000 in. in diameter. It occurs in pairs in groups principally within the cells of the exudation which forms on the membranes; it may also sometimes be found in the blood by culture. The meningococcus, when treated by the Gram staining process, remains uncoloured; it is readily cultivated on media containing serum, and by its cultural reactions can be distinguished from other similar micro-organisms, and does not develop at a temperature below about 75° F. The examination of the cerebro-spinal fluid for the presence of the meningococcus is now practised for purpose of diagnosis of the disease. No drug exerts any specific action upon the disease, but an "anti-meningococcic serum" is unquestionably sometimes a valuable curative agent, though at other times it fails. This variation in effect probably depends upon the fact that varieties of the meningococcus exist, and unless the serum has been prepared with the variety for which it is to be employed it is likely to fail.

The disease is undoubtedly spread by contact and possibly in other ways. The meningococcus is sometimes found located at the back of the throat, and may so exist not only in persons who have had the disease, but also in those who are seemingly healthy and have not suffered from the disease; such individuals constitute "carriers" and are sources of infection, and attempts have of late been made to detect such carriers by bacteriological examination, so that they may be isolated. Of preventive measures little of value is known, but recently a trial has been made of vaccinating with killed cultures of the meningococcus, with what result remains to be seen. The presence of the meningococcus in the throat has suggested that the organism enters the body and central nervous system *viâ* the nasal passages.

R. T. H.

## NOTES.

THE subject of the address to be delivered by Sir William Ramsay at the annual meeting of the British Science Guild to be held this afternoon is "The National Organisation of Science." Owing to the war, the annual dinner of the guild will not be held this year.

THE annual general meeting of the Eugenics Education Society will be held this afternoon at the Grafton Galleries, Grafton Street, W., and the presidential address will be delivered by Major Leonard Darwin upon the subject, "Eugenics During and After the War."

SIR ALMROTH WRIGHT has been awarded the Lecomte prize by the Paris Academy of Sciences. The prize, which is of the value of 2000*l*., is awarded triennially.

WE notice with much regret the announcement of the death on June 26, from heart failure, of Dr. R. H. Lock, inspector at the Board of Agriculture and Fisheries, sometime fellow of Gonville and Caius College, Cambridge, at thirty-six years of age.

MR. TENNANT said in the House of Commons on June 23 that practically all the laboratories in the country have been placed at the disposal of the War Office. Great benefit has been derived by the War Office from advice and information received from the Royal Society, the National Physical Laboratory, the universities, and other bodies, and Mr. Tennant took the opportunity of conveying to these scientific and learned bodies the thanks of the Army Council.

IN the House of Commons on June 28, Sir Philip Magnus asked the Prime Minister whether, having regard to the necessity for the purposes of the war of organising the services of fellows of the Royal Society and of other scientific bodies and also of the professors and staffs of our universities and technical schools, and of mobilising the scientific and technical resources of the laboratories and workshops of such institutions, and, having regard to the importance of creating a central committee or bureau for considering scientific problems that arise out of the war, for testing and developing inventions from whatever source they may originate, and reporting upon them to the special Department of State concerned, he will afford an opportunity of discussing the subject in the House? The reply of the Prime Minister was that opportunities would arise for this discussion.

A USEFUL ethnological collection has been made in Siberia by the University of Pennsylvania's expedition, according to news recently received in Philadelphia from its leader, Mr. H. U. Hall. Last summer was spent by the party among the Samoyed and Dolgan tribes, and last winter among the Tungus and Yakuts, between the Yenisei and Lena Rivers. The effect of the war has been felt by the expedition in raising the prices of everything and making "transportation" difficult.

THE annual meeting of the General Board of the National Physical Laboratory was held in the rooms of the Royal Society on Tuesday, June 15, when the annual report and accounts for the year 1914–15 were adopted for presentation to the president and council of the Royal Society, and the programme of work for the coming year was approved. This year the usual gathering of visitors at Teddington, to meet the members of the General Board and to inspect the laboratory, will not take place. Twenty-five per cent. of the staff are on active service.

THE council of the Royal Society of Arts has arranged with Prof. Vivian B. Lewes to give a short course of special lectures during the recess on "Modern Munitions of War." Three lectures will be given, on Wednesday afternoons, July 7, 14, and 21. The first lecture will deal with "Guns and Propellants," the second with "Mines, Shells, and High Explosives," and the third with "Poison Gases and Incendiary Bombs." The course will be under the Fothergill Trust. The lectures will be open to all fellows of the society, who can admit their friends personally, or by the usual tickets. Tickets will also be issued gratuitously to any persons interested in the subject who may apply to the secretary, Sir Henry Trueman Wood, at the offices of the society.

*Engineering* for June 25 announces the death of Mr. Charles Colson, C.B., late Deputy Civil Engineer-in-Chief of the Admiralty. Mr. Colson, who died at St. Leonards on June 8, at the age of seventy-six, was connected with the War Department in early life, and joined the Admiralty in 1866. For many years he was assistant-engineer on the Portsmouth Dockyard extension. In 1883 he was selected to go to Malta to design a new graving dock for the Navy at that port. He held the post of Superintending Civil Engineer of Devonport Dockyard from 1892 to 1894, when he was appointed Assistant-Director of Civil Engineering Works at the Admiralty. He was the author of a book on docks and dock construction which has been widely used, and he contributed several papers to the Proceedings of the Institution of Civil Engineers.

WE record with regret the death of Mr. Howard Marsh, master of Downing College, and professor of surgery in the University of Cambridge. He died at The Lodge, Downing College, on June 24, aged seventy-five. After receiving his training at St. Bartholomew's Hospital he applied himself to surgery, becoming lecturer on surgery at his school. He was justly regarded as a leading authority on diseases and treatment of joints. He was an active member of the council of the Royal College of Surgeons, advocating the enfranchisement of the members of the college. In 1903, when he had reached an age at which many consultant surgeons seek retirement, he entered a new field of endeavour as professor of surgery in the University of Cambridge, where his energy and public spirit were given full scope. In 1907 he became master of Downing, succeeding Dr. Alex. Hill. His predecessor in the chair of surgery was the late Sir George M. Humphry.

IT is a wonderful story, in the *Daily Chronicle* of June 23, of the death of Dr. Chaillou. He was head of the anti-rabies department of the Pasteur Institute

in Paris. Those of us who remember the war of 1870-71 will remember what havoc it made of Pasteur's work. The institute had not then been founded; the work was done in the laboratories in the rue d'Ulm. Pasteur's young men went off to the war; Henri Ste. Claire Deville met his death there. When Pasteur died, in 1895, Roux was his successor, as head of the institute. History repeats itself; the Pasteurians have gone off to the war; and Chaillou has met his death there. On April 21 he had "demanded and obtained the perilous mission of disinfecting a battlefield near the enemy's trenches." At night, alone, he "reconnoitred the position"; he found work enough for twelve nights; the state of the battlefield must not be described here. On the night of April 24 he was within seven yards of the enemy's trenches, and was killed. Strange, to think of this man of science, accustomed to work of the very utmost minuteness and microscopical accuracy, stumbling about, in the dark, with a tin of disinfecting powder, among the piles of unburied dead. Shells fell on him and his men: eleven were killed. Every day and every night precious lives, cultured and expert men, are flung away like this. We say that there will be a "shortage of doctors" when the war is over; but we scarcely stop to think of the tragedy in that off-hand phrase. The waste of the lives of the experts is terrible. Here was a man trained and disciplined in one of the most complex of all the sciences; and he is put to scavenging, to the very roughest and least skilled work, and he lays down his life for his friends over that. May his name live in the great institute where he worked more delicately for the good of mankind.

By the death of Dr. G. C. M. Mathison, which took place at Alexandria on May 20, in consequence of wounds received in Gallipoli, the sciences of physiology and pathology have suffered a serious loss. The taking away of young and enthusiastic workers, of which this is by no means the only instance, is one of the saddest things in the war. Dr. Mathison's chief scientific work was concerned with the analysis of the phenomena of asphyxia in its effects on the nervous system. He showed that the results both of deficient oxygen supply and also of increased accumulation of carbon dioxide are due to a common factor, namely, the rise of hydrogen-ion concentration in the blood. The various nerve centres were shown to be sensitive in different degrees to this agent; thus the bulbar centres are excited by one-fifth of the increase that the spinal centres require. In deprivation of oxygen without accumulation of carbon dioxide, it was shown that acids may be produced by disorganisation of the cells of the nerve centres themselves, a process which takes place suddenly and must be regarded as pathological. Deficiency of oxygen was found also to produce heart block by depression of conductivity in the auriculo-ventricular connection. In work done with the collaboration of Barcroft, Mathison showed that the rate at which oxyhæmoglobin gives up its oxygen to the tissues is greatly increased by a rise in the concentration of hydrogen ions, and that rises of such an extent as to be of importance in tissue respiration may occur when the oxygen supply is deficient. The effect of potassium on the vascular system was also investigated and found to be of a dual nature. While it is depressant on the heart, it produces contraction of the arterioles, both by direct action upon the muscular fibres and by excitation of vaso-constrictor centres in the spinal cord and the bulb.

THE death of Lieut. R. B. Woosnam, killed in action at the Dardanelles on June 4, adds one more name to the steadily increasing list of workers in science who have given up their lives for their country in this great war. Lieut. Woosnam served with the 2nd Worcestershire Regiment in the South African war, and it was during that period that he first became known to the Natural History Museum by sending to that institution a number of small mammal and bird skins prepared so well that it was at once noticed that they were the work of a skilled collector and true naturalist. At the close of the war Woosnam offered his services to the museum as a collector, and on the offer being accepted he gave up soldiering for the time being. In his new capacity he carried out a difficult piece of zoological exploration through the Kalahari desert to Lage Ngami, and in October, 1905, he was appointed leader of the important expedition organised by the museum for the exploration of the Ruwenzori range in equatorial Africa. His companions were Mr. R. E. Dent, a former brother officer in the Worcestershire Regiment, the Hon. Gerald Legge, Mr. Douglas Carruthers, and Mr. A. F. R. Wollaston. The expedition reached a height of 16,794 ft., and Woosnam records that butterflies, moths, and diptera were seen on the snow up to 16,000 ft., blown there by the almost constant wind. On the bare rocks above the snow-line a few worms, lichens, and mosses were seen. As a result of the undertaking the National Museum was enriched by a large number of species new to science, and a very valuable addition made to our knowledge of the fauna and flora of tropical Africa. In 1911 Woosnam was appointed by the Secretary of State for the Colonies game warden in British East Africa. He very quickly surmounted the difficulties of the position, and it speaks volumes for the fine nature of the man that though he carried out his duties in the strictest manner and confiscated with unsparing hand illegally obtained sporting trophies and other objects, there was no more popular official in the Protectorate. He was mainly instrumental in getting together the International Conference for the Protection of Wild Animals in Africa which met in London last year. It is no secret that he formulated stringent plans, which were virtually adopted, for the effective carrying out of the object of the conference. Now, alas! all this is at an end, and with it has passed away a man of sterling character, of a lovable disposition, modest and unassuming almost to a fault, an unflinching adherent to duty.

THE thirteenth annual session of the South African Association for the Advancement of Science will be held at Pretoria, from Monday, July 5, to Saturday, July 10, inclusive, under the presidency of Mr. R. T. A. Innes, Union Astronomer. The sections and their presidents will be as follows:—*A*—Astronomy, Mathe-

matics, Physics, Meteorology, Geodesy, Surveying, Engineering, Architecture, and Irrigation, F. E. Kanthack; *B*—Chemistry, Geology, Metallurgy, Mineralogy, and Geography, H. Kynaston; *C*—Bacteriology, Botany, Zoology, Agriculture, Forestry, Physiology, Hygiene, and Sanitary Science, C. P. Lounsbury; *D*—Anthropology, Ethnology, Education, History, Mental Science, Philology, Political Economy, Sociology, and Statistics, J. E. Adamson. Among the papers to be read are the following:—The fault system of the south of Africa, Prof. E. H. L. Schwarz; Some South African radio-active minerals, Prof. P. D. Hahn; Darwin's theory of natural selection, tested in the light of our knowledge of Crassulaceæ, Prof. S. Schönland; The economy of termites, C. Fuller; The history of the ostrich industry in South Africa, R. W. Thornton; Anti-venomous serum and its preparation, F. W. FitzSimons; The inheritance and characters of certain cross-bred sheep, J. Burtt-Davy; The Baganano (Malaboch), with notes on the traditional history of the tribe, Rev. N. Roberts; Sesuto etymologies, Rev. W. A. Norton; practical education, W. J. Horne; and The economics of the east coast fever, Rev. J. R. L. Kingon. A popular evening discourse will be delivered by Mr. C. W. Mally, on the house-fly under South African conditions, and one by Dr. E. T. Mellor on the Witwatersrand Goldfields. The medal and grant for 1915 have been awarded to Mr. C. P. Lounsbury, chief of the division of entomology, Union Department of Agriculture, and will be presented during the session.

THE National Clean Milk Society (2 Soho Square, London, W.), which has been formed to improve the milk supply of Great Britain and Ireland, has published a pamphlet showing how by a system of marks it is possible to conduct the inspection of dairy farms in an efficient and educational manner. The score-card system which has been developed so largely in the United States for judging stock, agricultural produce, etc., has also been applied to the inspection of dairy farms, town dairies, etc. By making alterations that would bring the score-card more in touch with British conditions, it has been possible to arrive at what promises to be a most satisfactory way of judging of the sanitary condition of any farm that is producing milk for human consumption. The score-card is divided into two main sections, one section dealing with equipment, the other with methods, and 60 per cent. of the total marks is allotted to the latter. Most excellent explanatory notes are appended to the score-card, and are presumably intended for the guidance of the inspector. A perusal of them would be of great value to the farmer himself, for frequently lack of cleanliness is due more to failure to appreciate the necessity of being careful in the handling of such an important food as milk than to any desire to evade regulations. Sanitary inspectors in particular should see this pamphlet, and if every landowner would take the trouble to observe how large a proportion of marks on the score-card depend upon the cowshed there might be improvements in farm buildings.

DR. R. HAMLYN-HARRIS, the director of the Queensland Museum, has set himself the task of forming a collection of the "Implements of Superstition and Magic" used by the natives of Queensland. As these are dying out with appalling rapidity, ethnologists the world over will be grateful to him. A most welcome summary of the results so far achieved appears in vol. iii. of the Memoirs of the Queensland Museum. He prefaces his account with a word of warning which in the interests of science cannot be too widely circulated. The wily aboriginal, having discovered that his implements and weapons have a marketable value, has taken to manufacture on an extensive scale, but such specimens bear, in every detail, the mark of the bungler. Nevertheless, it would seem that tons of material are being exported to museums all over the world by unscrupulous dealers who are inciting the natives to pursue this reprehensible means of obtaining money or its equivalent. Death-bones, quartz crystals, magic stones, and rain-sticks are severally described in this essay, which contains a valuable collection of myths and customs which are fast disappearing.

THE concluding portion of the paper by Prof. Flinders Petrie on the Stone age in Egypt, published in *Ancient Egypt*, part iii., for 1915, raises a very interesting question of synchronism. The writer notices a striking resemblance between the coarse flakes which abound in prehistoric Egyptian graves with those of the Magdalenian Cave type. In other cases the snubbing of the edge by scraping is characteristic of European Aurignacian flints. The Magdalenian flint types in Egypt are associated with bone harpoons, which are also of that age in Europe. A bone harpoon found in Egypt belongs to the first and part of the second prehistoric civilisation, say 8000-6000 B.C. "This," he writes, "raises the question whether it will be possible to extend the Magdalenian Cave period as late as the Egyptian graves of about 7000 B.C., or to trace a descent of the type to a later time. This connection is an additional reason for keeping to the Egyptian chronology, and not adopting the arbitrary theories of Berlin which would bring down these Magdalenian types to about 3500 B.C." This suggestion of a possible synchronism between the Cave periods of Europe and graves in Egypt which can be dated with some approach to certainty may lead to important results. It is unfortunate that so much haphazard collection of flints has gone on in Egypt, without regard to their seriation or characteristics, and thus evidence of much value has been lost.

THE Miocene insect beds of Florissant, Colorado, promise to yield an even richer harvest than the celebrated beds of Oeningen in Baden. Prof. T. D. A. Cockerell, in the Proceedings of the Academy of Natural Sciences of Philadelphia (part iii., vol. lxvi.), describes a number of species new to science collected by Prof. Wickham. In an excavation about 20 ft. long and 6 ft. deep he obtained more than ninety species of beetles, of which at least forty are new to science. But various other groups are also represented in this collection, of which apparently sixty are new species.

A NEW addition to the list of British fishes is made by Dr. R. F. Scharff in the *Irish Naturalist* for June. This is the long-finned bream (*Brama longipennis*) which was captured on May 18 last year, off the west coast of Valencia Island, Co. Kerry. Though brilliantly coloured at the time of capture, by the time it had reached the island it had faded to a uniform grey hue. Only one other species of the genus has been recorded from Irish waters. This is Ray's bream (*Brama raii*), which was recorded in 1888. To the same number Dr. Scharff contributes some interesting notes on Irish sharks.

THOUGH observations on the birds attracted to lightships and lighthouses during migration have been kept with much exactness during a number of years, no similar records had been made in regard to insects which in like manner are attracted by light, until recently, when the matter was taken up by Mr. W. Evans. The conclusion of his report on Lepidoptera and other insects at Scottish lighthouses appears in the *Scottish Naturalist* for June. It is usual, he remarks, "to think of moths alone as night-fliers, and attracted by light, but . . . not a few other insects have similar habits, and are similarly attracted. . . . Both sexes come to the lanterns, but as a rule males predominate." He also makes some interesting observations on the dominance of certain colour variations.

CONCHOLOGISTS will doubtless welcome the announcement of the rediscovery of Pourtales's Haliotis. This is made by Mr. J. B. Henderson in the Proceedings of the U.S. National Museum (vol. xlviii., 1915). The first intimation of the occurrence of this genus in western Atlantic waters dates so far back as 1869, when a specimen was dredged up in the Straits of Florida. This was unfortunately destroyed in the great Chicago fire before it could be described. Twenty years later it was described from memory by Dr. Dall, who named it in honour of Count Pourtales, under whose supervision the original dredging operations were carried out. Two years ago Mr. Henderson, while dredging from the *Eolis*, along the inner edge of the Pourtales Plateau off West Key, in ninety fathoms, secured a second specimen of Haliotis, which proved on examination to be an immature specimen of the long-lost Pourtalesii.

THE reclamation of peat bogs is always a matter of economic importance, and the results achieved by sowing *Pinus pinaster* directly on a peat-bog, described in *Irish Gardening* for June, are worthy of wider notice. Two photographs are reproduced, one showing the depth of the peat where the seeds were sown in the west of Ireland, the other three of the young trees, four years old. The soil is fatal to the Scots Pine, but *P. pinaster*, if sown on the spot, thrives remarkably. The tree transplants badly, and for this reason the success attending the method adopted at Abbeyleix by Mr. Macgregor is very interesting.

No. XXVIII. of vol. vi. of Notes from the Royal Botanic Gardens, Edinburgh, for May, is occupied by a useful paper in the form of a key to the Labiatæ of China, by Mr. S. T. Dunn. The key is based largely on the collections in the Hong Kong herbarium, and has been constructed on practical lines. Hong Kong being essentially the key to the botanical position as regards China, we welcome any work, based on the collections of that herbarium, tending to set out in orderly form the vast wealth of the Chinese flora as regards particular natural families. Even now it is not possible to arrive at a definite phytogeographical survey of the empire as regards any one group of plants, but a key such as that just published is of value in helping forward the more detailed study of the flora of China.

THE condition known as Peloria, in which the exceptional development of complementary irregularities make a typically irregular flower regular, is fairly commonly met with in foxgloves and snapdragons under cultivation; indeed, in both plants a definite varietal form, with either the terminal or all the flowers peloric or regular, appears to be fixed and to come true from seed. In the foxglove the variety is known as var. *monstrosa*, and the terminal flower is a more or less regular erect bell, similar to the flower of a Campanula. In Antirrhinum a varietal form has been so far fixed by Lorenz, of Erfurt, that 60 per cent. of the plants raised from seeds bear peloric flowers; this form is figured in "Gartenflora" (1904, p. 113, t. 1524). Here all the flowers are tubular and perfectly regular, but a form recently received from a correspondent resembles the foxglove, variety *monstrosa*, in having the terminal flower only regular, with the characteristic lower lip of the snapdragon, forming a complete fringe round the actinomorphic tubular flower, while all the other flowers are zygomorphic. A further peculiarity of these pleoric varieties is that the terminal flower of the raceme is the first to open, whilst in normal forms the terminal flower is the last to expand.

HELMHOLTZ'S magnification formula of our elementary text-books on optics is known to be a particular case of a number of interesting reciprocal theorems; for example, the property that in a system of lenses the *angular* diameters of the object and image as seen from any position are inversely proportional to the *linear* diameters of the sections of the incident and emergent small pencils where they meet the eye. In the *Atti dei Lincei*, xxiv., 7, Prof. Levi Civita gives a general dynamical investigation of these reciprocal relations, including Straubel's theorem, and with applications to multi-dimensional hyperspace. This is based on the analogy between trajections in dynamics and paths of rays, which analogy results from the principles of least action and time respectively.

THE rapid increase of the electrical resistance of pure iron with temperature makes it very desirable that the behaviour of iron resistance thermometers should be thoroughly investigated with a view to their introduction into common use. Such an investigation has been made by Messrs. G. K. Burgess and I. N. Kellberg, of the United States Bureau of Standards, and the results are published in the May number of the journal of the bureau. The wire used was 99·98 per cent. iron, 0·24 millimetre in diameter, and was wound on a porcelain insulator and enclosed with

a similar platinum wire in an evacuted quartz tube. Six such combined thermometers were made and annealed at 1000° C. In the subsequent comparisons of the resistances of the platinum and iron wires at various temperatures the resistances were determined to the equivalent of 0·005° C. In all cases the resistance of pure iron was found to increase regularly to about 750° C., the temperature coefficient of increase reaching a maximum about seven times that of platinum at that point. At 757° C. the critical point A2 is reached, and the coefficient decreases. At 894° C. the second critical point, A3, is reached, and the resistance decreases over a range of 10° C., to increase again at higher temperatures. On cooling the A3 change occurs at 880° C., while the A2 change occurs again at 757° C.

THE June issue of the *Journal* of the Franklin Institute contains a second paper by Sir Robert Hadfield on sound steel for rails and structural purposes, the first having been published in February. The present paper gives some details of the production for the Pennsylvania Railway Company of one hundred tons of rail ingots made at Sheffield under his "sound steel" system. The dimensions of the ingots were 5 ft. 4 in. by 18 in. square. They were fed from sandheads, which permitted an average of 130 lb. of fluid steel to pass into the ingot, which contracted during freezing, thus continuously "following up" any pipe that tended to be formed. The average capacity of the cavity on the top of the ingots was 3·19 per cent. of the total capacity of the ingot. The author claims that after cutting off 10 per cent. from the top of the ingot the remaining 90 per cent. is sound, entirely free from blowholes, segregation, or piping. Ingots sectioned through the long axis and photographed appear to bear out this contention, at any rate so far as soundness is concerned. In the rail ingot, as ordinarily cast, a discard of upwards of 40 per cent. is sometimes necessary, and even in the sound portion segregation is always present to a greater or less extent. It is interesting to note that the average carbon percentage in the ingots is 0·63—a considerably higher figure than any English railway company permits. This gives a harder but more brittle rail. The wear in practice of rails rolled from these ingots will be watched with considerable interest.

THE *Scientific American* celebrated its seventieth anniversary on June 5, and the number for this date contains an interesting retrospect through the inventions and scientific discoveries of the past seventy years. When the journal was first established, we had only Davy's arc and electrolysis, Oersted and Ampère's revelations in electrodynamics, Daguerre's photography, Henry and Faraday's work in induction, and Joule's mechanical equivalent of heat. The telegraph and the reaper had just been born. Much of the transformation which has marked the last seventy years has taken place within the lives of men still with us. Prior to the invention of the telephone, our contemporary considers that the decade 1840–50 was the most fruitful in invention; during this period the reaper, the vulcanisation of rubber, the sewing-machine, and the telegraph were perfected. The decade beginning with 1880 saw an outburst of inventive activity that dwarfed all similar periods in the history of invention. It seemed that the discoveries in electricity during the last three or four years of the previous decade had been the signal for the pent-up genius of the world to be let loose. In the 'eighties the generation, transmission, and utilisation of current, the dynamo, the transformer, and the motor were all made practical propositions on a large and commercial scale for the first time. The electric furnace was perfected in the latter part of this period. The Harvey process for hardening armour plate was invented in 1888; smokeless powder, the Westinghouse brake, the transparent film which foreshadowed the moving picture and the pneumatic tyre are also contributions of the same decade. There are a large number of photographs of historical inventions and inventors included in this number, and there is also an interesting autobiographical sketch by Mr. Nikola Tesla.

IN view of the great interest at the present time in the Conventions and signed Declarations of the First and Second Hague Conferences, and particularly because of the need of accurate information as to ratifications of and adhesions to the Conventions and Declarations relating to war, the Carnegie Endowment for International Peace has prepared a series of pamphlets in order that the public may learn from trustworthy sources the status of these international agreements and the extent to which the Powers now at war are bound by their provisions. We have received copies from Washington of seventeen of these pamphlets, and find that among the subjects of vital importance considered are: the declarations of 1899 concerning asphyxiating gases and expanding bullets, and prohibiting the discharge of projectiles and explosives from balloons; and the conventions of 1907 relative to the laying of automatic submarine contact mines and concerning bombardment by naval forces in time of war.

THE Open Court Company, 149 Strand, W.C., has ready for publication "A Budget of Paradoxes," by Augustus de Morgan, revised and edited, with full bibliographical notes and index, by Prof. David Eugene Smith, professor of mathematics, Teachers College, Columbia University, New York.

MESSRS. G. P. PUTNAM'S SONS announce for early publication:—"The Alligator and its Allies," by Prof. A. M. Reese; "Plane Trigonometry," by Prof. A. M. Harding and J. S. Turner; and "Field Book of Western Wild Flowers," by M. Armstrong and Prof. J. J. Thornber.

THE announcements of the Cambridge University Press include:—"Mimicry in Butterflies," by Prof. R. C. Punnett; "The North-West and North-East Passages, 1576–1611," edited by P. F. Alexander (the first volume in the series of "Cambridge Travel Books"); and "Stories of Exploration and Discovery," by A. B. Archer.

ERRATA.—In Prof. O. W. Richardson's Royal Institution discourse printed in NATURE of June 24, p. 468, col. 2, line 12, for "twice" read "half"; p. 469, col. 1, table, for "calories per n" read "calories per gram-molecule of electrons."

## OUR ASTRONOMICAL COLUMN.

THE ORIGIN OF COMETS.—In the *Publikationer og mindre Meddelelser fra Kobenhavns Observatorium*, No. 19, Prof. Elis Strömgren publishes a research which he has concluded with the help of Mr. J. Braae on the subject of the origin of comets. In the introduction the author refers to the results of previous workers, and suggests that the question as to whether comets came originally from interstellar space or were formed in the solar system, depends on the method of discussion adopted. The author describes fully the procedure he has used in the present research, which involves the backward computation of planetary perturbations for eight comets, and gives the numerical calculations. He is thus led to form the conclusions that there is not one warranted hyperbolic orbit among the comets of the solar system, and that all the comets yet observed have their origin in the solar system.

COMPANIONS TO MELLISH'S COMET.—In the Astronomical Notes of the May–June number of the Journal of the Royal Astronomical Society of Canada, reference is made to two companion bodies near Mellish's comet discovered by Prof. Barnard. One of these bodies was conspicuous and had a distance of 28″ and position angle of 285° on May 12 at 19h. 36m. The other was faint, and occupied an intermediate position on the same line. The above confirmation appeared in the Harvard College Observatory Bulletin, No. 580.

THE ABERRATION CONSTANT AND LATITUDE VARIATION.—The floating zenith-telescope designed by the late Mr. Bryan Cookson has been in use since 1911 at the Royal Observatory, Greenwich, having been lent by the Cambridge University. It has been employed in the determination of the aberration constant, and a preliminary discussion by Mr. H. S. Jones of three years' observations with it appears in the May number of the Monthly Notices of the Royal Astronomical Society. This communication represents the results derived from observations made between September, 1911, and December 31, 1914, and the discussion is based on measures of 479 plates. The value of the aberration obtained is given as 20·467″ ±0·006.″ The instrument being designed primarily for the determination of the aberration, it is interesting to note that, as a by-product of the investigation, excellent values of the latitude variation have been derived. The paper contains a representation in the form of curves of the Cookson results, the international results, and the latter without the Z or Kimura term. The Cookson latitude variation is more in agreement with the last-mentioned curve, and it is pointed out that the agreement on the whole is improved, and more particularly so during the latter half of 1913, when the Z term attained its greatest value during this period.

THE HENRY DRAPER MEMORIAL.—In the work of the classification of the spectra of stars Miss Annie Cannon's name is well known, and as an able member of the staff of the Harvard College Observatory her position renders her admirably suited to describe the pioneer work and progress of the Henry Draper Memorial. Under this title Miss Cannon communicates to the May–June number of the Journal of the Royal Astronomical Society of Canada a most interesting account of the work that has been carried on at both the Cambridge and Arequipa stations of the Harvard College Observatory in the name of Henry Draper, the memorial having been presented by Anna Palmer Draper, the widow of that distinguished investigator and astronomer. A very clear survey is given of the progress of the many lines of research undertaken and successfully accomplished, but these cannot be referred to here, for they are too numerous and space forbids. The enormous amount of data collected in the form of glass negatives is now being adequately dealt with by the generosity of Mr. George Agassiz, and the work of identification and reduction placed on a scientific basis. To give an idea of the work (other than observational) being done at the present time, Miss Cannon states that 199,196 spectra have been classified, and about 150,000 of these have been identified. It is hoped that the observations for the New Draper Catalogue will be finished in six months, and that the printing will be started soon after that time. It is proposed then to make a very careful study of the distribution of the various classes of stellar spectra, "as a portion of the contribution of the Henry Draper Memorial to the greatest of all investigations, the constitution of the sidereal universe." Attention should be directed to the excellent reproductions, which include a portrait of Henry Draper, views of the Cambridge and Arequipa stations, types of stellar spectra, spectra of stars in region of R Cygni, and many others.

THE REPORT OF THE CAMBRIDGE OBSERVATORY, 1914–15.—In the *Cambridge University Reporter* for June 19 a report is given of the proceedings in the Cambridge Observatory for the period May 19, 1914, to May 18, 1915. The director states that for various reasons not much progress could be made with observational work during the first half of the year under review, but from the beginning of 1915 the conditions of work became more normal. The Sheepshanks equatorial has been the chief instrument in use, and this has been mostly employed in securing photographs to complete the series of plates required for the parallax programme. At present the exposures at each epoch are made on separate plates, but it is hoped ultimately to secure the exposures at the two epochs on the same plate. The meridian circle has been confined to observations for time determination. The Northumberland equatorial seems to be used only on Saturday evenings during term time for the members of the University and their friends. As regards publications, the printing of the Ledger of the Zone Catalogue is near completion so far as the main catalogue is concerned.

## THE DESTRUCTION OF FLIES.

A PAPER on "The Destruction of Flies and the Disinfection of Corpses in the Battle Line," by M. E. Roubaud, is published in the *Comptes rendus* of the Paris Academy of Sciences for May 25. The author remarks that the hot weather will bring with it the menace of fly outbreaks and consequent epidemics of diseases, and that he has collected the simplest methods of dealing with the problem. For house-flies, he recommends heavy coal tar oils sprayed on the surface of excrement, etc., to prevent access of flies; for sanitary purposes he advises the following:—

| | | |
|---|---|---|
| Ferric sulphate | ... ... | 2500 grams. |
| Heavy tar oil | ... ... | 500 c.c. |
| Water | ... ... ... | 10 litres. |

This is stated to be deodorising, larvicidal, and protective against flies.

Heavy tar oils are toxic to plants, and cannot be used when the material is to be employed as manure. Shale oils (miscible oils) he considers more toxic to plants than to larvæ, and he deprecates their use. Cresyl—*i.e.* miscible cresol—at 5 per cent. in water is not harmful to plants, and manure heaps are to be treated with 15 litres (four gallons) per superficial cubic metre. The exposed areas of the manure heap are then to be protected with a watering of 10 per cent. solution of ferric sulphate. This double treatment is to be carried out twice, in June and in

August; fresh manure as added is to be treated with ferric sulphate.

In regard to blow-flies, M. Roubaud discusses means of preventing access of flies to dead bodies, and the disinfection of corpses. In the first he states that heavy tar oil is to be used, as it preserves animal tissues when 10 per cent. cresyl, chloride of lime, formol, milk of lime, and 5 per cent. phenol fail to do so. Ferric sulphate is to be used as a protective covering, either powdered on or applied as 10 to 20 per cent. solution. The salt forms stable compounds with the tissues which cannot be attacked by flies, and the solution kills eggs and larvæ; the three substances required at the front then are ferric sulphate, heavy tar oil, and cresol.

Some of the author's statements, which are given without proofs, cannot be unreservedly endorsed; for example, it is practically certain that a dead horse powdered with ferric sulphate will still breed innumerable flies unless it is periodically treated. No superficial treatment will clear a superficially dry manure heap of maggots; only a vapour treatment applied in liquid form. Also, a 10 per cent. solution of ferric sulphate is a very expensive dressing unless the substance is available in enormous amount; and one of the difficulties of the front is the transport of material. Concentrated treatments are required if possible, not 10 per cent. treatments at great bulk.

The problem of dealing with flies is very difficult, and is receiving much attention. One aspect is being carefully dealt with in this country, and the results will be available very shortly. This is the question of the treatment of the great aggregation of stable manure. The War Office have apparently accepted the American view of the value of borax; already a treatment with volatile liquid at a third of the present cost of borax has been found, which is satisfactory in that it spreads in the manure heaps and is not simply a superficial treatment; and it does not affect the value of the manure for horticultural purposes. Plants will stand very strong applications of volatile organic compounds, far stronger than are required to kill fly maggots, but which compounds are the best has yet to be determined.

## AIR POLLUTION.

THE Air Pollution Advisory Board of the Sanitary Committee of the Corporation of Manchester has recently issued its first report. We are told that this Board came into existence two years ago as the result of a memorial presented to the Corporation by members of various scientific and other societies in the city with the object of examining the latest and best methods of eliminating the smoke evil and of diffusing information on the subject.

The Board consists of representatives of various committees of the Corporation, distinguished men of science, and influential members of numerous public bodies. It is divided into four sections, namely, the chemical, statistical, administrative, and engineering sub-committees. This is not the first occasion on which the public spirit of Manchester citizens has been inspired by the smoke nuisance and exercised itself in an attempt to suppress it. In 1891 a committee of the town gardening section of the Manchester Sanitary Society issued a report on some of the evils of smoke affecting vegetation and the amount of daylight; and in 1895 a "committee for testing smoke-preventing appliances" published a voluminous and comprehensive report on the various forms of apparatus used in steam boilers which were alleged to diminish or remove smoke.

What the ultimate fate of these two committees was, the writer is unable to say; but though their activities ceased, there is no doubt that they stimulated an interest in the subject which led not only to the formation of the present Board, but had the effect of inducing other municipalities to adopt a similar action. Work of the same character is now being carried on in fifteen other cities. This growing interest which has spread out from Manchester in ever-widening circles also led to the formation of a Local Government Board Committee on Smoke Abatement, which held numerous meetings in the first half of last year.

The present report deals mainly with the amount, nature, and extent of air pollution by smoke. The methods, which need not be described in detail, are based upon previous investigations of this character, and the results are not essentially different from those already recorded by other observers.

Valuable as the information is as indicating the extent of atmospheric contamination (which is as injurious as it is wasteful and unnecessary) and in keeping public interest alive to the importance of the economic use of fuel, the accumulation of statistics of a nature already well authenticated will not of itself bring about any radical reform.

We are glad to see, therefore, that the Board has in contemplation the study of all domestic coal-consuming grates and their efficiency, and an extensive propaganda by pamphlets, lectures, and exhibitions among builders and tenants in relation to domestic heating by coal, coke, gas, and electricity. Although a good deal of pioneer work has been done in this direction by various smoke abatement societies, it is just one of the subjects on which the views of the community are so firmly welded to the past that unremitting agitation is necessary before the deeply-rooted tradition in the efficacy of the old-fashioned coal fire can be loosened. When this work is complete, the time will be ripe for the consideration of more drastic measures of smoke abatement, and there is no doubt that had not the advent of the war postponed the deliberations of the Smoke Abatement Committee of the Local Government Board, the report of that committee would have greatly strengthened the hands of the municipalities in any future legislation which they may have in view.

In conclusion, we can only congratulate the Manchester Sanitary Committee on the scientific way in which it has set about steadily accumulating evidence and wish it a full measure of success in achieving its ultimate object.

J. B. C.

## RADIATIONS FROM EXPLODING ATOMS.[1]

IT is now well established that the radio-active substances are undergoing spontaneous transformation, and that their characteristic radiations—the $\alpha$, $\beta$, and $\gamma$ rays—accompany the actual disintegration of the atoms. The transformation of each atom results from an atomic explosion of an exceedingly violent character, and in general results in a liberation of energy many million times greater than from an equal mass of matter in the most vigorous chemical reaction.

In the majority of cases the atomic explosion is accompanied by the expulsion of an actual atom of matter—an $\alpha$ particle—with a very high speed. It is known that the $\alpha$ particle is an atom of helium which carries two unit positive charges, and which leaves the atom with a velocity of about 10,000 miles per second. In some transformations no $\alpha$ particle is ejected, but its place is taken by a swift $\beta$ particle or electron. These $\beta$ rays carry with them

[1] Discourse delivered at the Royal Institution on Friday, June 4, by Sir Ernest Rutherford, F.R.S.

a large amount of energy, for in some cases they are expelled very close to the velocity of light, which is the limiting velocity possible for such particles. The expulsion of high-speed $\beta$ particles is usually accompanied by the appearance of $\gamma$ rays, which correspond to X-rays, only of greater penetrating power than has so far been obtained from an X-ray tube even when a high voltage is employed. The emission of energy in the form of $\gamma$ rays is not negligible, for in some cases it is even greater than the energy emitted in the form of high-speed $\beta$ particles, and may amount per atom to as much as 20 per cent. of the energy released in the form of a swift $\alpha$ particle.

By the application of a high voltage to a vacuum tube it is quite possible to produce types of radiation analogous to those spontaneously arising from radium. For example, if helium were one of the residual gases in the tube, some of its atoms would become charged, and would be set into swift motion in the strong electric field. In order, however, to acquire a velocity equal to the velocity of expulsion of an $\alpha$ particle, say, from radium C, even in the most favourable case nearly four million volts would have to be applied to the tube.

In a similar way, in order to set an electron in motion with a velocity of 98 per cent. the velocity of light, at least two million volts would be necessary. As we have seen, it has not so far been found possible to produce X-rays from a vacuum tube as penetrating as the $\gamma$ rays. The study of the radiations from radio-active substances is thus of especial interest, not only for the information obtained on the structure of the atoms themselves, but also in providing for investigation special types of radiation of greater individual intensity than can be obtained by ordinary experimental methods. The enormous energy of motion of swift $\alpha$ and $\beta$ particles must exist in the atom before its disintegration, either in a potential or a kinetic form, and may arise either from the passage of the charged particles through the intense electric fields within the atom, or from the very swift motion of these particles within the atom before their release. In any case, there can be no doubt that electric fields, and possibly magnetic fields, of enormous intensity exist within the very small volume occupied by the essential structure of the atom—fields many million times greater in intensity than we can hope to produce in laboratory experiments.

In order to explain certain experimental results, I have suggested that the main mass of the atom is concentrated within a minute volume or nucleus, which has a positive charge, and is of dimensions exceedingly minute compared with the diameter of the atom. This charged nucleus is surrounded by a distribution of electrons which may extend to distances comparable with the diameter of the atom, as ordinarily understood. The general evidence indicates that the $\alpha$ and primary $\beta$ particles are expelled from the nucleus, and not from the outer structure of the atom. If this be the case, the $\alpha$ particle which carries a positive charge would have its velocity increased in passing through the strong repulsive field surrounding the nucleus; on the other hand, the $\beta$ particle which carries a negative charge must be retarded in its escape from the nucleus, and must possess great initial energy of motion to escape at all. There appears to be no doubt that the penetrating $\gamma$ rays have their origin in some sort of disturbance in the rings of electrons nearest to the nucleus, but do not represent, as some have supposed, the vibrations of the nucleus itself.

### $\alpha$ *Rays.*

A brief account was given of the recent work of Rutherford and Robinson in determining with accuracy the velocity of expulsion of the $\alpha$ particles from certain radio-active substances. This was done by measuring the deflection of a pencil of $\alpha$ rays in strong magnetic and electric fields. With the aid of intense sources of radiation, it was found that the value of E/M—the ratio of the charge carried by the $\alpha$ particle carried to its mass—was 4820 units, a value to be expected if helium has an atomic weight 4 and carries two unit charges. This experiment also shows that the mass of the flying positive particle is not affected appreciably by its swift motion. From known data the initial velocity of the expulsion of the $\alpha$ particles from all other radio-active substances can be deduced with accuracy.

If the expulsion of an $\alpha$ particle from an atom is the result of an internal explosion, we should anticipate, from the analogy of a shot from a gun, that the residual atom would recoil in a direction opposite to the escaping $\beta$ particle. The existence of these "recoil" atoms can be shown in a variety of ways, for the velocity of recoil is sufficient to cause the atoms to leave the surface on which they are deposited and to pass through a considerable distance in air at a pressure of one millimetre before they are stopped. It is to be anticipated that the momentum of a recoiling atom should be equal and opposite to that of the escaping $\alpha$ particle. Since the deflection of a charged particle in motion in a magnetic field is inversely proportional to its momentum, the deflection of a stream of recoiling atoms should be the same as for the $\alpha$ particles if the atoms carry the same charge. Dr. Makower has examined the deflection of a pencil of recoil atoms in a magnetic field, and found it to be exactly half of that due to the $\alpha$ particle, proving definitely that the recoiling atom carries only one unit of positive charge in place of two for the $\alpha$ particle.

We thus see that the simple application of momentum enables us to deduce the mass and energy of the recoiling atoms. Since the mass of the radio-active atoms is about fifty times that of the $\alpha$ particle, the velocity, and also the energy, of recoil is only about 1/50th of that of the escaping $\alpha$ particle. In a similar way, it can be shown that the ejection of a swift $\beta$ particle should cause a vigorous recoil of the atom, though not so marked as in the case of the more massive $\alpha$ particle.

### $\beta$ *Rays.*

During the last few years notable advances have been made in our knowledge of the mode of emission of $\beta$ particles from radio-active atoms. The work of Baeyer, Hahn, and Meitner, and of Danysz, has shown that the $\beta$ rays from a radio-active substance like radium B or radium C contain a number of definite groups of rays which are expelled with definite velocities. This is best shown photographically by examining the deflection of a pencil of $\beta$ rays in a magnetic field. In a uniform field, each of the groups of rays describes a circular path the radius of which is inversely proportional to the momentum of the $\beta$ particle. By the application of special methods it has been found possible to obtain a veritable spectrum of the $\beta$ rays. The spectrum of the $\beta$ rays from radium B and radium C has been very carefully examined by the writer and Mr. Robinson, and found to give a large number of well-marked bands, each of which represents a group of $\beta$ rays, all of which are expelled with identical speed. It was at first thought that most of the energy of the $\beta$ rays was comprised in these groups, as some of the bands on the photographic plate were very marked. Chadwick, however, has recently shown that the fraction of the rays which give a line spectrum is only a few per cent. of the total radiation. The general evidence shows that the $\beta$ radiation from these substances gives a *continuous*

spectrum due to $\beta$ rays of all possible velocities, on which is superimposed a *line* spectrum due to a small number of $\beta$ particles of definite velocity comprising each group.

Lines in the $\beta$-ray spectrum have been observed for particles which have a velocity not far from that of light, but the photographic effect of the particles becomes relatively feeble for such high speeds.

It is known from direct measurement that each atom of radium B or of radium C in its disintegration emits *on an average* one $\beta$ particle. In the $\beta$-ray spectrum of radium C at least fifty definite bands are observed, differing widely in intensity. It is thus clear that a single atom in disintegrating cannot provide one $\beta$ particle for *each* of these numerous groups. It is thus necessary to conclude that each atom does not emit an identical $\beta$ radiation. The results are best explained by supposing that the $\beta$-ray spectrum is the statistical effect due to a large number of atoms, each of which may only give one or two of the groups in its disintegration. In this respect a $\beta$-ray transformation is distinguished from an $\alpha$-ray transformation, for in the latter case each atom emits one $\alpha$ particle of characteristic speed. It will be seen later that there is undoubtedly a very close connection between the emission of $\beta$ and $\gamma$ rays from radio-active atoms, and the probable explanation of the remarkably complex $\beta$-ray spectrum will be discussed later.

With the exception of one element, radium E, and possibly uranium X, all the radio-active substances which emit primary $\beta$ rays give a line spectrum. For the majority of elements the strong lines in the $\beta$-ray spectrum have been determined by Baeyer, Hahn, and Meitner, but more intense sources of radiation will be necessary to map accurately the weaker lines.

### $\gamma$ *Rays.*

The earlier experiments on the $\gamma$ rays were mainly confined to a determination of the absorption of the more penetrating radiations by different kinds of matter. It was early observed, however, that some of the radiations appeared to be complex. This was shown by anomalies in the initial part of the absorption curve. In the meantime, a notable advance in our knowledge of X-rays had been made by the work of Barkla. He found that under certain conditions each element when bombarded by X-rays of suitable penetrating power gave rise to a strong radiation which was characteristic for that element, *e.g.*, the lighter elements from aluminium to silver emitted characteristic radiations called the "K" series, which increased rapidly in penetrating power with the atomic weight of the radiator. It was found that the heavier elements emitted in addition another characteristic radiation of softer type, which was called the "L" series. These results showed clearly that there must be definite structures within the atom which gave rise to a definite radiation under suitable conditions of excitation. From these results it seemed probable that the $\gamma$ rays from radio-active matter must consist of the characteristic radiations of these heavy elements, analogous in type to the corresponding radiations observed in ordinary elements when excited by X-rays or kathode rays. These conclusions were confirmed by a series of investigations made by Rutherford and Richardson. The $\gamma$ rays were analysed by means of their absorption by aluminium and by lead, the disturbing effects of the primary $\beta$ rays being eliminated by means of a strong magnetic field. It was found, for example, that the $\gamma$ rays from radium B, when examined by their absorption in aluminium, consisted of at least two types, one easily absorbed, and the other eighty times more penetrating. By further observations of the absorption of the $\gamma$ rays by lead, Richardson found that the rays from radium B could be divided into at least four definite types, each of which was absorbed exponentially by lead. Similar results were obtained for all the radio-active elements which emitted $\gamma$ rays. In some cases the soft $\gamma$ rays, *e.g.*, those from radium B, corresponded to the characteristic radiation of the "L" series, and others to the "K" series. The general results, however, indicated that several additional series of characteristic radiations are present in some cases. It was clear from these experiments that the $\gamma$ rays corresponded to the natural modes of vibration of the inner structure of the radio-active atoms. In the meantime the experiments of W. H. Bragg and W. L. Bragg, and of Moseley and Darwin, had shown that the characteristic X-radiations of the elements gave definite and well-marked line spectra. These spectra were simply determined by reflecting the rays from crystals. If this were the case, it seemed probable that the $\gamma$ rays from the radio-active atoms would also give line spectra, and thus allow the natural frequencies of vibration of these atoms to be determined. During the past year, a number of experiments have been made to test this point by Rutherford and Andrade, using radium B and radium C as the source of $\gamma$ radiation. As was anticipated, it was found that the $\gamma$ rays from radium B and radium C gave well-marked line spectra. The general method employed was to use an $\alpha$-ray tube containing a large quantity of emanation as a source of radiation. The $\gamma$ rays were reflected from a crystal of rock salt, and the position of the spectrum lines determined photographically. Usually twenty-four hours were necessary to obtain a marked photographic effect. Special difficulties arose in these experiments which are absent in an investigation of a similar kind with X-rays. In addition to $\gamma$ rays, the radio-active matter emits very penetrating $\beta$ rays which have a strong photographic action; while the $\gamma$ rays in their passage through matter themselves give rise to high-speed $\beta$ rays. The disturbing effect of these radiations has to be eliminated by placing the whole apparatus between the poles of a powerful electromagnet. In this way it was found that the spectrum of radium B consisted of a large number of lines, of which the most intense were deflected at angles of 1° 46′, 10°, and 12°. The more penetrating radiation from radium C gave a strong line of 1° and a fainter line at 43′. The strong lines at 10° and 12° are due to easily absorbed $\gamma$ rays, and undoubtedly correspond to the "L" radiation of radium B. The line at 1° corresponds to a very penetrating radiation which has a wave-length less than 1/10th of an Angström unit. The penetrating $\gamma$ rays from radium C have by far the shortest wave-length so far observed. It does not seem probable that such short waves can be produced artificially in an X-ray tube unless possibly an exceedingly high voltage be applied.

There is one interesting result of these investigations that should be mentioned. The two strong lines of the radium B spectrum deflected at 10° and 12° were found to correspond exactly in position to the X-ray spectrum of lead. These experiments thus confirmed the view based on chemical evidence that radium B and lead were isotopic, *i.e.*, they were elements of practically identical chemical and physical properties, although their atomic weight differed by seven units.

### *Connection between $\beta$ and $\gamma$ Rays.*

Before considering in detail the difficult problem of the connection between $\beta$ and $\gamma$ rays, it is desirable to summarise the main facts that have been established in regard to the relations between kathode rays and X-rays:—

(1) A small part of the energy of kathode rays falling on a radiator is converted into X-rays, the average frequency of the latter increasing with the velocity of the kathode particle.

(2) X-rays in passing through matter give rise to a $\beta$ radiation. The initial energy of the escape of the electrons increases with the frequency, and is probably proportional to it.

(3) Electrons or X-rays of appropriate energy are equally able to excite the characteristic radiations in an atom.

The results which have been shown to hold for the X-rays hold equally for the $\beta$ and $\gamma$ rays, which have much greater individual energies, *e.g.* Gray and Richardson have shown that the $\beta$ rays from radio-active matter are able to excite the characteristic radiations of the elements in a number of substances, while $\gamma$ rays in passing through matter give rise to high-speed electrons. It was long ago suggested by Bragg that $\beta$ rays and X-rays are mutually convertible forms of energy, *e.g.* a $\beta$ particle falling on matter may be converted into an X-ray of the same energy, and the latter in passing through matter may in turn be converted into an electron of identical energy. This assumes that the energy of an X-ray and an electron are mutually convertible, and the energy may appear under suitable conditions in either of the two forms. While the general evidence indicates that this point of view may hold closely for the conversion of the energy of a single X-ray into that of a swift electron, it is very doubtful whether it holds for the converse case of the excitation of an X-ray into an electron. We shall see later from experimental evidence that in general the energy of the electron required to excite an X-ray of definite frequency is always greater than the corresponding energy carried off in the form of an X-ray.

It was early observed that there appeared to be a close connection between the emission of $\beta$ and $\gamma$ rays from radio-active matter. In all cases, the two types of radiation appeared together. A closer examination, however, showed that there were very marked differences between the relative energies of the $\beta$ and $\gamma$ rays from different radio-active elements. For example, radium C emits intense $\beta$ rays and also intense $\gamma$ rays; on the other hand, radium E emits intense $\beta$ rays over a wide range of velocity, but exceedingly weak $\gamma$ rays. Differences of a similar kind were observed amongst a number of the radio-active elements. One striking distinction, however, was to be noted. All the radio-active substances which give a marked line spectrum of $\beta$ rays also emitted intense $\gamma$ rays. On the other hand, a substance like radium E, which gave scarcely any $\gamma$ rays at all, gave a continuous spectrum of $\beta$ rays in which no lines have so far been observed. It thus appeared probable that the line spectrum of the $\beta$ rays was intimately connected with the emission of $\gamma$ rays, and this conclusion has been completely established by recent experiments. As we have seen, $\gamma$ rays in passing through matter give rise to high-speed $\beta$ rays. Using radium B and radium C as a source of $\gamma$ rays, the $\beta$ radiation excited in a number of metals by the passage of $\gamma$ rays was analysed in a magnetic field by Messrs. Robinson and Rawlinson and the writer, and was found to consist in part of definite groups of $\beta$ rays. When lead was the absorbing material, the magnetic spectrum of the $\beta$ rays excited by the $\gamma$ rays was found to be nearly identical with the primary $\beta$-ray spectrum of radium B. This striking result shows that those $\beta$ rays escaping from the radio-active atom which give rise to a line spectrum must result from the conversion of $\gamma$ rays into $\beta$ rays in the radio-active atom. The slight differences observed in the spectrum for different metals is probably connected with the energy required to excite one of the characteristic radiations of the element used as absorber.

An explanation of the marked differences in the character of the $\beta$ and $\gamma$ radiation from different radio-active atoms can, I think, be given on the following lines. Some of the $\gamma$ rays are broken up in their escape from the atoms, and the energy of each converted $\gamma$ ray is transferred to an electron which escapes with a definite velocity dependent on the frequency of the $\gamma$ radiation. Taking into account a large collection of disintegrating atoms, each of the possible modes of characteristic vibration of the atom gives rise to an electron of definite speed. In this general way we may account for the line spectrum of the $\beta$ rays which is so commonly observed. On this view, we should expect to obtain a well-marked line spectrum of $\beta$ rays when a substance emits strong $\gamma$ rays—a result in accord with observation.

In order to account for the marked differences in the types and intensity of $\gamma$ rays from different radio-active substances, it seems necessary to suppose in addition that the primary $\beta$ particle always escapes from the nucleus in a *fixed* direction with regard to the structure of the atoms under consideration. For example, we have already pointed out that radium E, although it emits intense $\beta$ rays which give a continuous spectrum over a wide range of velocity, emits very weak $\gamma$ rays. Since there can be no doubt that the $\beta$ rays have sufficient speed to excite the characteristic modes of vibration which must be present in the atom, we are driven to the conclusion that the $\beta$ particle escapes in such a direction that it does not pass through these vibrating centres. On this view, the type of characteristic $\gamma$ rays which are excited, and consequently also the corresponding speed of the $\beta$ rays which arise from the converted $\gamma$ rays, will depend entirely on the direction of escape of the primary $\beta$ particle. The definite direction of escape of the primary $\beta$ particle, which varies for atoms of different substances, also suffices to explain a number of other differences observed in the mode of release of energy from various radio-active atoms. It is supported by many other observations which indicate that the atoms of a particular radio-active substance break up in an identical fashion.

We have so far considered only in a qualitative way the relation between the groups of rays in a $\beta$-ray spectrum and the emission of characteristic $\gamma$ rays. During the last few years there has been a growing body of evidence that the energy E carried off in an X-ray of frequency $\nu$ is proportional to this frequency, and is given by $E=h\nu$ where $h$ is Planck's fundamental constant. If the whole of the energy of an X-ray can be given directly to an electron, the energy communicated to the latter should be $h\nu$. There is no doubt that in many cases this simple relation holds very approximately, but the measurements so far available are not sufficiently precise to settle definitely whether a part of the energy may not appear in another form.

Assuming that the transfer of the energy from an X-ray to an electron is complete, we should expect to find groups of $\beta$ rays of energy corresponding to $h\nu$ where $\nu$ is the frequency of the $\gamma$ rays found experimentally. Such a relation is found to hold within the limit of experimental error for three marked groups of low velocity $\beta$ rays emitted from radium B. On the other hand, it is found that many of the high-velocity groups of $\beta$ rays from both radium B and radium C have energies many times greater than correspond to any observed frequency. Not the slightest evidence, however, has been obtained that corresponding high frequencies of vibration exist in the radio-active atom; in fact, all the evidence points

to the fact that these high-speed electrons arise from one or more of the observed frequencies in the γ-ray spectrum.

In order to account for such results, it seems necessary to suppose that the γ rays of high frequency are not necessarily emitted as single pulses, but consist of a train of pulses either produced simultaneously or following one another at very short intervals. Each of these pulses has an energy $h\nu$ corresponding to the frequency $\nu$, but the total energy in the train of waves is $ph\nu$ where $p$ is a whole number, which may have possible integral values 0, 1, 2, 3, . . . etc., depending on the structure of the atom and the conditions of excitation. The penetrating power of such a train of waves corresponds to that of a single wave of frequency $\nu$, but on passing through matter the energy of the whole train of $p$ waves occasionally may be transferred to an electron which consequently is expelled with an energy $ph\nu$. There is very strong evidence of the general correctness of this point of view, for most of the stronger lines in the β-ray spectrum of radium C have energies which correspond to an *integral* multiple of the energy corresponding to the strong lines actually observed in the γ-ray spectrum. It seems probable that under the ordinary conditions of excitation by kathode rays in a vacuum tube, the X-ray contains only one pulse or wave, but under the far more powerful stimulus of the very swift β particle escaping from the atom, a long train of waves, each of the same frequency, is produced. The energy of the whole train of waves may under suitable conditions be given to an electron, which consequently has a speed very much greater than that impressed upon it by a single wave of the same frequency.

*Limit to the Frequency of Vibration of the Atom.*

There is one question of fundamental importance which arises in considering the modes of vibration of the atom, viz. whether there is a definite limit to the frequency of the radiation which can be excited in a given atom. Theory does not provide us with an answer to this problem, since little is known about the conditions of excitation, nor even of the nature of such high-frequency vibrations. A study of the frequency of the γ rays from radio-active substances is of great importance, as it throws much light on this problem.

As we have seen, the energy of the β particle escaping from the nucleus of radium C is equivalent to that acquired by an electron moving in an exhausted space under a potential difference of several million volts. This high-speed electron passes through the electronic distribution in its escape from the atom. Notwithstanding such ideal conditions for the excitation of high-frequency radiations of the atom, the highest frequency in the radiation emitted by radium C is only about twice that obtainable from an ordinary hard X-ray tube excited by 100,000 volts. It thus appears probable that there is a definite limit to the frequency of the radiation obtainable from a given atom, however high the speed of the disturbing electron. This limiting frequency is determined not by the speed of the electron but by the actual structure of the atom. Since the γ radiation from radium C gives a line spectrum, it would appear that the highest frequency obtainable is due to a definite system of electrons which is set into characteristic vibration by the escape of a β particle. In order to throw further light on this point, Prof. Barnes, Mr. H. Richardson and myself have recently made experiments to determine the maximum frequency obtainable from an X-ray tube for different constant voltages. The Coolidge tube, which has recently been put on the market, is ideal for this purpose, as it provides powerful radiation at any desired voltage. The anti-kathode is of tungsten of atomic weight 184, so that we are dealing in this case with the possible modes of vibration of a heavy atom. The maximum frequency of the radiation was deduced by measuring the absorption by aluminium of the most penetrating rays emitted at different voltages. The absorption of X-rays of different frequencies by aluminium has been examined over a very wide range, and can be expressed by simple formula. It was found that for 20,000 volts the frequency of the radiation was slightly lower than that to be expected if Planck's relation held. With increasing voltage there is a rapid departure from Planck's relation. The frequency reaches a maximum at about 145,000 volts, and no increase was observable up to the maximum voltage employed, viz. 175,000 volts. The experiments thus show that the frequency of radiation reaches a definite maximum, which is no doubt dependent on the atomic weight of the particular radiator employed. It is of interest to note that the maximum penetrating power of the X-rays from the Coolidge tube in aluminium is about the same as the γ rays from radium B, but is about 3/10 of the γ rays from radium C. There is evidence which suggests that the very penetrating γ rays from radium C correspond to the octave of the "K" characteristic radiation of that element. If this be the case, it may prove possible that a still more penetrating radiation might be obtained from tungsten, but in order to excite it a voltage of the order of a million volts would probably be required. In any case, it seems clear that Planck's relation does not hold for excitation of high frequencies by swift electrons, but may hold very approximately for lower frequencies corresponding to the radiation excited by a few hundreds or thousands of volts. On the other hand, the evidence obtained from a study of the β rays excited by X-rays or γ rays certainly indicates that the relation $E = h\nu$ holds at any rate very approximately for the highest frequency examined. It is thus obvious that the emission of β and γ rays from the radio-active atoms is clearly connected with the general theory of radiation, and it seems likely that a close study of these radiations will throw much light on the mechanism of radiation in general.

There can be little doubt that the penetrating γ rays from active matter have their origin in the vibration of electronic systems in the structure of the atom outside the nucleus. The nucleus itself, however, must be violently disturbed by the expulsion of an α or β particle. If this leads to the emission of a γ radiation, it must be of exceedingly high frequency, as the forces holding together the component parts of the nucleus must be exceedingly intense. We should anticipate that this radiation would be extraordinarily penetrating, and difficult to detect by electrical methods. So far no experimental evidence has been obtained of the existence of such very high frequency radiations, but it may be necessary to devise special methods before we can hope to do so.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Reference is made in the *Times* of June 25 to the large number of Cambridge men now on active service; from a "War List" which has just been issued it appears that 8885 members of the University are with the colours. The official list gives the names of those who have been killed or wounded in action, and it appears that for every four who have been wounded three have been killed. This is due to the fact that most of the Cambridge men serving are either 1st or 2nd lieutenants.

EDINBURGH.—Since the beginning of the war the Officers Training Corps of the University has supplied 686 commissioned officers: artillery, 234; infantry, 288; engineers, 79; medical corps, 85. In addition many others have been under training as the University Reserve. Both in the 15th Royal Scots and in the 14th Argyll and Sutherland Highlanders, a nucleus of a company has been formed by University students. During the summer term a large part of the engineering building and the neighbouring class-room of applied mathematics have been used by the School of Instruction for Commissioned Officers. Systematic courses are being given and are being attended by seventy-five infantry officers and twenty-four artillery officers. The hours are from 9 a.m. to 6 p.m., and each officer under instruction is expected to read for two or three hours every night. Qualifying examinations are held at the end of each month's instruction. The adjutant who has charge of the School of Instruction is Major Mackenzie, one of the University lecturers in chemistry, and one of the instructors is Lieut. Todd, lecturer in engineering. These facts will give some idea of the way in which Edinburgh University men are answering to the call.

GLASGOW.—The Senate has appointed Dr. S. Alexander, professor of philosophy in the University of Manchester, to the post of Gifford lecturer for the period 1916–18.

LONDON.—Mr. G. F. Goodchild, principal of the Wandsworth Technical Institute, has been appointed to the post of registrar of the Council for External Students, in succession to Mr. Alfred Milnes.

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IT is announced in *Science* that by the will of Miss Helen Collamore, of Boston, 20,000*l.* is bequeathed to Simmons College, 4000*l.* to Radcliffe College, and 2000*l.* primarily to aid women students in post-graduate courses in the Massachusetts Institute of Technology.

To commemorate the services rendered to the Ocean Steamship Company, Ltd., by the two founders of the company, the late Mr. Alfred Holt and the late Mr. Philip Henry Holt, a sum of 20,000*l.* has been handed by the company to the Holt Education Trust, and the income is to be applied in perpetuity by the trustees for the purpose of higher education in Liverpool.

THE successful series of public lectures on the Empire, by Dr. H. B. Gray, the official lecturer, will be continued at the Imperial Institute throughout July. The lectures, which are now illustrated by lantern slides, are followed in each case by a visit to the exhibition galleries of the Imperial Institute, which afford a unique object-lesson in the Empire's commercial capacities. The lectures for July, which will be given on Wednesdays at 3 o'clock punctually, are as follows:—July 7, British West Africa; July 14, Fiji, Western Pacific, and Falkland Islands; July 21, Egypt and the Sudan. Admission is free by ticket, to be obtained at the central stand in the exhibition galleries, Imperial Institute, South Kensington, S.W.

THE recent report of the Board of Education (Cd. 7934) for the year 1913–14 remarks with regret that no improvement in the provision of higher technical instruction in day technical classes is shown in the figures relating to 1912–13. In that year twenty-six institutions provided technical institution courses, the total number of separate courses in these institutions being seventy-eight. Of these, nineteen were courses in preparation for matriculation or other examinations forming stages towards university degrees, fifty-four were technological courses in engineering, chemistry, and subjects connected with the building, mining, textile, and leather trades, many of which were also attended by some students preparing for degrees, and five were scientific courses mainly in provision for professional qualifications. The total number of students enrolled in the courses was 1464. The number of students taking the full courses was 1236, of whom 539 were in their first year, 374 in their second year, 269 in their third year, and fifty-four in later years of their courses. The number of day technical classes, as distinct from courses, recognised in 1912–13 was 281, and these were held in 110 institutions. The students in attendance numbered 12,970. Of the courses held, 131 were only part-time or short full-time courses. The other 150 were in the nature of full-time day schools. While the latter was approximately the same in number as in the previous year, there has been a fall of thirty-nine in the case of the part-time courses.

THE Professional Classes War Relief Council has issued a report of six months' work which shows not only the need that existed for such an organisation, but the variety of means that have been employed. The applications during the six months which ended on May 6 numbered 2000, and the number of cases dealt with is 1600. One hundred cases were referred to other societies. Among the most useful forms of assistance have been temporary employment, education and training, financial help and loans, medical help, and hospitality. The professions dealt with have included authors, analytical chemists, engineers, surveyors, and teachers. In the matter of education 1120*l.* has been expended. Through the generosity of headmasters and various governing bodies, 134 children who would otherwise have lost all education are becoming pupils at reduced fees, and in many cases the assistance given to pupils also enables schools to continue which would otherwise have been ruined. In addition to this thirty-three candidates are undergoing training in productive professions; four have already qualified and have obtained remunerative employment, and others are about to take up their work. The work of the council does not perhaps lend itself to picturesque description, but it is filling an important place in our present disturbed social conditions. The expenditure is now at the rate of 43*l.* per week, and unless a sum of 25,000*l.* can be raised in the next few months the work cannot be continued. No other body is doing exactly the same kind of work, in trying by co-ordination of existing benevolent funds, as well as by its own specialised forms of assistance, to tide over the professional classes who are so heavily penalised by the war. The offices of the council are 13 and 14 Prince's Gate, S.W.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, June 17.—Sir William Crookes, president, in the chair.—Dr. E. J. **Russell**: Soil protozoa and soil bacteria. In view of the claim recently made by Goodey that soil protozoa cannot function as a factor limiting the numbers of bacteria in soils, the author has brought together the evidence on which this view is based. It has been shown in numerous experiments that the numbers of bacteria in normal soils are relatively low, but they can be raised by any treatment that kills trophic forms and not spores. Starting, in the first instance, to find the properties of the factor which keeps down the bacterial numbers, and without framing any hypothesis as to its nature, these were found to be: (*a*) active, and not a lack of some essential; (*b*) not bacterial; (*c*) extinguished by heat or poisons, and after extinction does not reappear; (*d*) can be reintroduced by adding a little untreated soil; (*e*) is favoured by conditions favourable to trophic life in the soil. These properties indicate that the

factor is biological. Search was therefore made for organisms fulfilling these conditions and numbers of protozoa were found. Definite evidence has been obtained that trophic forms occur as normal inhabitants of the soil, and the estimates of numbers so far available show that they are considerable. There is the closest possible relationship between the extinction of the protozoa and the extinction of the limiting factor, and also between the re-establishment of the protozoan fauna and the setting up of the limiting factor after reinfection with small quantities of soil.—Prof. W. M. **Hicks**: The enhanced series of lines in spectra of the alkaline earths. A discussion of the enhanced series of the alkaline earths is carried out in order to determine their relation to the sun. For this purpose the results given for Mg, Ca, Sr by Fowler in his recent Bakerian Lecture are used, and, in addition, the corresponding series in Ba and Ra are considered. It is found that the quantity $\Delta'$, giving the doublet separations, is given with great accuracy in terms of the oun, as follows:—Mg, $56\frac{1}{2}\delta$; Ca, $68\delta$; Sr, $58\delta$; Ba, $56\frac{1}{2}\delta$; Ra, $60\frac{1}{2}\delta$; where $\delta$ is four times the corresponding oun for the element. The satellite separations are also found as functions of the same quantity. Further it is shown that these series strongly support the general relations given in a former communication that the first *p*-sequence depends on a multiple of the atomic volume, and that the diffuse sequence is such that the denominators of the first lines, when the wave number is expressed in the form $A-N/(den)^2$, are themselves multiples of $\Delta'$ or of the oun.—Prof. H. F. **Baker**: Certain linear differential equations of astronomical interest. This paper is written to exemplify the application of a general method for the solution of linear differential equations given by the author some years ago. The method furnishes solutions in a form valid for an indefinitely extended region. It is here applied (1) to establish a result as to the convergence of the solution of a particular equation, apparently in disagreement with a conclusion reached by Poincaré in his "Méthodes Nouvelles de la Mécanique Céleste"; (2) to place the general method given by Laplace for the absorption of the time in astronomical series under trigonometrical signs in connection with the ordinary theory of characteristic exponents; (3) to discuss in general terms the oscillations of a dynamical system about any given possible state of motion; (4) to furnish a regular calculus for the solution of the equation used by G. W. Hill for the motion of the moon's perigee, and similar equations. The earlier part of the paper discusses particular equations from a less formal point of view, and has seemed necessary in order to place the matter in proper light. One particular problem discussed is that of the stability of three bodies of any masses moving in ellipses at the angular points of an equilateral triangle, a matter of which the discussion has recently been revived.—Prof. Karl **Pearson**: The partial correlation-ratio. The general theory of mutiple correlation has been long established, and is summed up in the discussion of two constants—the partial correlation coefficient and the multiple correlation coefficient. If there be $m$ variates, $1, 2, 3 \ldots m$, then the partial correlation coefficient of the $(m-2)^{nd}$ order is related to the multiple correlation coefficients of the $(m-1)^{th}$ and $(m-2)^{nd}$ orders by the equation:—

$$1-{}_{34\cdots m}\rho^2_{1\cdot 2}=\frac{1-R^2_{1\cdot 234\cdots m}}{1-R^2_{1\cdot 34\cdots m}}.$$

The object of the present paper is to give the corresponding equation for show-regression. It is known that the value of the above relation is exactly commensurate with the linearity of the regression, a condition not synonymous with but embracing as a special case gaussian or normal distributions of frequency. When the regression is not linear, nor the partial variations homoscedastic in distribution, then the statistician has to use, in order to represent by a single coefficient the association of two variables, the correlation-ratio, usually symbolised by $\eta$. The use of the correlation-ratio has been hampered by the absence of any generalised theory in the case of multiple variates. If ${}_{34\cdots m}\eta_{1\cdot 2}$ be the partial correlation-ratio of the first variate on the second for constant third, fourth ... $m^{th}$ variates and $H_{1\cdot 23\cdots m}$ be the multiple correlation-ratio for 1 on 2, 3 ... $m$, then the fundamental formula is—

$$1-{}_{34\cdots m}\eta^2_{1\cdot 2}=\frac{1-H^2_{1\cdot 234\cdots m}}{1-H^2_{1\cdot 3\cdots m}}.$$

The paper shows that there are only three independent first order partial correlation-ratios and gives the formulæ for these, and for higher order correlation-ratios in terms of the multiple ratios and lower order partial ratios.—S. **Skinner** and F. **Entwistle**: The effect of temperature on the hissing of water when flowing through a constricted tube. The experiments deal with the temperature coefficient of the effect described by Osborne Reynolds before the British Association at Oxford, 1894. It is shown that the velocity at which hissing just occurs between 0° and 100° C. suffers a diminution which may be expressed by a formula $V_t=-c(t-\theta)$, where $V_t$ is the velocity of the stream at a temperature $t$, and $\theta$ the critical temperature of water, and $c$ a constant. It is argued that this result forms a measure of the tensile strength of the liquid, and consequently it brings the phenomenon of hissing into relation with the other properties of a liquid.—J. C. **McLennan** and J. P. **Henderson**: Ionisation potentials of mercury, cadmium, and zinc, and the single and many-lined spectra of these elements. (1) It is shown that a spectrum consisting of a single line is obtainable for mercury, for zinc, and for cadmium. (2) The wave-lengths of these lines are, for mercury, $\lambda=2536{\cdot}72$ Å.U.; for zinc, $\lambda=3075{\cdot}99$ Å.U.; and for cadmium, $\lambda=3260{\cdot}17$ Å.U. (3) The minimum ionisation potentials for mercury, zinc, and cadmium are shown to be 4·9 volts, 3·74 volts, and 3·96 volts respectively. (4) Some considerations are presented which support Sir J. J. Thomson's theory of the two-type ionisation of atoms of mercury, and others which suggest that the theory is applicable as well to the ionisation of atoms of zinc and cadmium. (5) The minimum arcing potential differences which will bring out the many-lined spectra of mercury, zinc, and cadmium vapours are found to be 12·5 volts, 11·8 volts, and 15·3 volts respectively. These voltages are also probably the minimum ionisation potentials of the second type for the atoms of these three elements. (6) Considerations are presented which suggest the possibility of analysing the spectrum of an element in such a way as to enable one to correlate different portions of the spectrum with disturbances in definite portions of the atomic structure of that element.—Dr. A. E. H. **Tutton**: The monoclinic sulphates containing ammonium.—Completion of the double sulphate series. In this communication are described the five remaining double sulphates of the series $R_2M(SO_4)_2.6H_2O$, in which R is ammonium and M is nickel, cobalt, manganese, copper, and cadmium. The present memoir completes the author's work on the double sulphates of this series. The main conclusions are the following:—(1) These ammonium salts are truly isomorphous with the similarly constituted potassium, rubidium, and cæsium salts of the generic formula above given, but are not eutropic with them; the potassium, rubidium, and cæsium salts alone form the exclusive eutropic series in which the crystallographical proper-

ties (both morphological and physical) obey the law of progression with the atomic weight of the alkali metal which has been established in previous communications. This law is particularly well illustrated by the fact, to which no exceptions have been observed, that average change of angle between crystal faces, and also maximum change of interfacial angle (which exceeds two whole degrees), are directly proportional to change in atomic weight when any one alkali metal is replaced by another. (2) The dimensions of the space-lattice of any ammonium salt of the series are nearly identical with those of the intermediate rubidium salt, so that the two atoms of rubidium are replaced by the ten atoms of the $2NH_4$ radicle-groups without appreciably altering the crystallographic structural dimensions. (3) The salts of the series in which R is thallium (also studied in a previous memoir) resemble the ammonium salts closely, in truly belonging to the isomorphous series, but not to the more exclusive eutropic series formed by the salts of potassium, rubidium, and cæsium. Like the ammonium salts, they also closely resemble the rubidium salts, but the thallium salts are distinguished optically, possessing transcendent refractive power, both their refractive indices and their molecular refraction being far higher than for any other salts of the whole isomorphous series.—E. B. R. **Prideaux**: General equations for the neutralisation of dibasic acids, and their use to calculate the acidity of dilute carbonate solutions.—Prof. H. A. **Wilson**: The electrical conductivity and luminosity of flames containing salt vapours.—T. R. **Merton**: A spectrum associated with carbon in relation to the Wolf-Rayet stars.—Sir Wm. **Abney** and Prof. W. **Watson**: The threshold of vision for different coloured lights.—Lord **Rayleigh**: Hydrodynamical problems suggested by Pitot's tubes.—Prof. M. C. **Potter**: Electrical effects accompanying the decomposition of organic compounds. II.—Ionisation of the gases produced during fermentation.—Prof. E. W. **MacBride** and A. **Jackson**: The inheritance of colour in the stick-insect (*Carausius morosus*).—Sir Francis **Darwin**: The relation between transpiration and stomatal aperture.—D. M. S. **Watson**: The monotreme skull—a contribution to mammalian morphogenesis.

**Mineralogical Society**, June 15.—Dr. A. E. H. Tutton, president, in the chair.—G. M. **Davies**: Detrital andalusite in Cretaceous and Eocene sands. Detrital andalusite is not confined to Pliocene and later deposits as was formerly supposed, but is a frequent constituent throughout the Cretaceous and Eocene beds of the south-east of England. In the lower Cretaceous beds it is still perfectly fresh, and shows no signs of instability under the influence of meteoric water.—J. F. N. **Green**: The garnets and streaky rocks of the English Lake District. Certain peculiar rocks occurring in the Lake District are characterised by almandine garnets and parallel streaks of secondary minerals. The capricious distribution of the garnets in diverse rock-types was considered to exclude originality, and thermal or dynamic alterations were shown to be inadequate. Circulating solutions under pressure during the solfataric stage of the Borrowdale episode were suggested as the agent, and illustrations were given of the replacement of felspar by garnet in Lake District rocks. The same origin was assigned to the streaky infiltrations which frequently contain pyrites or garnet.—Dr. S. **Kôzu**: The errors in the angle of the optic axes resulting from those of the principal refraction indices determined by total reflection. The indices so found are correct within 0·0002 for sodium light. Assuming the error to be only half this, the extreme values of the angle are for anorthite, 76° 8·6′, and 79° 21·8′; for albite, 76° 14·1′ and 80° 46·9′; and adularia 56° 16·9′ and 65° 56·9′.—Dr. S. **Kôzu**: The influence of temperature on the optic axial angle of sanidine from the Eifel. Pockels has shown that in those rhombic crystals in which the axial angle varies considerably in the neighbourhood of zero the relations between the angle and the temperature is represented by a parabola. Sanidine from the Eifel very nearly approaches the conditions of a rhombic crystal. The values of $2E$ were determined for seven different wave-lengths. The plotted curves were found to accord with Pockels's statement; further, the complex curves for the various wave-lengths were identical.—Dr. G. T. **Prior**: The meteoric stones of Warbreccan, Queensland. Three stones, weighing respectively about 69, 64, and 1 lb., were known to the natives of central Queensland before 1904, and their fall was probably seen. They were acquired by the British Museum in 1905. They are white-veined chondrites, and in chemical and mineral composition are similar to other members of the group.—A. F. **Hallimond**: Autunite. It is concluded that the Cornish material is essentially different from the Autun mineral, and the name bassetite is proposed for the former, the fundamental characters of which are:—Oblique, $\beta = 89° 17'$, $a : b : c = 0·3473 : 1 : 0·3456$; forms, 010, 110, 120, 011, 111, 121, $\bar{1}21$, $\bar{1}41$, $\bar{1}01$; twinning by parallel growth of $a$ and $c$ axes, perfect cleavage parallel to 010, also 100, 001; yellow, transparent; biaxial, $2E = 110°$; pleochroic, pale to deep yellow; soluble in acids.

**Linnean Society**, June 17.—Prof. E. B. Poulton, president, in the chair.—The four following papers were reports on materials brought home by Prof. J. Stanley Gardiner from the expedition to the Indian Ocean in H.M.S. *Sealark* in 1905:—E. T. **Browne**: Medusæ from the Indian Ocean.—Prof. A. **Dendy**: (1) Report on the Hexactinellid sponges (Triaxonida); (2) Continuation (Tetraxonida).—J. C. **Robson**: The Cephalopoda obtained.

## PARIS.

**Academy of Sciences**, June 21.—M. Ed. Perrier in the chair.—J. **Boussinesq**: The extreme slowness of cooling in the deep parts of the earth's crust, and an attempt to estimate, starting from a certain period, the progress of the solidification.—Paul **Brück**: Observations of the Mellish comet (1915*a*) made at the Observatory of Besançon with the 33 cm. equatorial. Eleven positions of the comet are given for March 16, April 13, 15, 16, 17, May 14 and 15.—René **Garnier**: The representations of the integrals of the equations of M. Painlevé by means of the theory of linear equations.—M. de **Broglie**: The spectra of the homogeneous secondary X-rays. A claim for priority as regards a recent paper on the same subject by M. Glagolev.—E. **Raverot**: A temperature interval regarded in relation to mechanical measurements. Starting with the numerical coincidence that the erg is $0·2381 \times 10^{-7}$ calories, and the specific heat of air at constant pressure is 0·2382 calories, the joule (0·238 cal.) is defined as the quantity of calorific energy corresponding to a variation of volume of the mass of 1 gram of air of 1/273 of its volume at 0° C., at the constant pressure of the atmosphere.—Léon **Bouthillon**: The charge of condensers by means of a constant electromotive force and their discharge in a spark circuit. Whatever may be the kind of spark-gap employed, the conditions under which a musical note is produced are the stable conditions under which the system is self-regulating.—G. A. Le **Roy**: The measurement of the waterproof qualities of cloths and military fabrics. The percolating water falls on a dry filter paper impregnated with a salt, and establishes an electrical circuit. The apparatus can be made recording, and does not re-

quire watching.—J. **Deprat**: The modifications in the structure of the Fusulinidæ from the Dinantian to the end of the Permian.—Pereira de **Sousa**: The earthquakes at Algarve (southern Portugal) from 1911 to 1914. These appear to be of epirogenic origin.—B. **Galitzine**: The earthquake of February 18, 1911. This earthquake coincided with a great rock slide at Sarez, in the Pamir, which filled up the valley of Mourgab and transformed it into a lake. The author concludes that this rock fall was not the consequence, but the cause of, the seismic disturbance registered at so many stations.—J. **Clarens**: The estimation of urinary acidity.—H. **Busquet**: The mode of action of colloidal gold: the production of cardiac effects by particles of metal not in solution. From a study of the effects of the injection of colloidal gold into the dog and rabbit, it is concluded that the immediate effects on the heart cannot be attributed to gold in solution, but must be produced by the suspended colloidal particles.—H. **Stassano**: The sterilisation of microbial cultures or emulsions by heat in thin layers.—Em. **Bourquelot**, M. **Bridel**, and A. **Aubry**: Researches on the glucosidification of glycerol by β-glucosidose (emulsin). The product obtained by the biochemical synthesis contained two glucosides, differing in their rotatory power and resistance to the action of emulsine.

## BOOKS RECEIVED.

Lessons and Experiments on Scientific Hygiene and Temperance for Elementary School Children. By H. Coomber. Pp. xx+163. (London: Macmillan and Co., Ltd.) 1*s*. net.

Indian Mathematics. By G. R. Kaye. Pp. 73 (Calcutta and Simla: Thacker, Spink and Co.)

Numerical Examples in Physics. By H. S. Jones. Pp. xii+332. (London: G. Bell and Sons, Ltd.) 3*s*. 6*d*.

Citrus Fruits. By Dr. J. E. Coit. Pp. xx+520. (New York: The Macmillan Company; London: Macmillan and Co., Ltd.) 8*s*. 6*d*. net.

The Principles of Rural Credits as Applied in Europe and as Suggested for America. By J. B. Morman. Pp. xviii+296. (New York: The Macmillan Company; London: Macmillan and Co., Ltd.) 5*s*. 6*d*. net.

The Mutation Factor in Evolution, with Particular Reference to Œnothera. By Dr. R. R. Gates. Pp. xiv+353. (London: Macmillan and Co., Ltd.) 10*s*. net.

Plant-Life. By C. A. Hall. Pp. xi+380. (London: A. and C. Black, Ltd.) 20*s*. net.

The Analysis of Dyestuffs and their Identification in Dyed and Coloured Materials, Lake-Pigments, Foodstuffs, etc. By Prof. A. G. Green. Pp. ix+144. (London: C. Griffin and Co., Ltd.) 8*s*. 6*d*. net.

The Aeroplane. By A. Fage. Pp. viii+136. (London: C. Griffin and Co., Ltd.) 6*s*. net.

Aero Engines. By G. A. Burls. Pp. x+196. (London: C. Griffin and Co., Ltd.) 8*s*. 6*d*. net.

Laboratory Work for Coal-Mining Students. By J. Sim and A. M. Wylie. Pp. viii+136. (London: E. Arnold.) 2*s*. 6*d*. net.

Meteorology of Australia. Commonwealth Bureau of Meteorology. Results of Rainfall Observations made in Queensland, including all Available Annual Rainfall Totals from 1040 Stations for all Years of Record up to 1013, together with Maps and Diagrams. Pp. 285. (Melbourne: A. J. Mullett.) 10*s*. 6*d*.

Staffordshire. By W. B. Smith. Pp. xi+155. (Cambridge: At the University Press.) 1*s*. 6*d*. net.

The Strength of Materials. By E. S. Andrews. Pp. x+604. (London: Chapman and Hall, Ltd.) 10*s*. 6*d*. net.

Climbing Plants. By W. Watson. Pp. x+132+ plates. (London and Edinburgh: T. C. and E. C. Jack.) 2*s*. 6*d*. net.

The Analysis of Non-Ferrous Alloys. By F. Ibbotson and L. Aitchison. Pp. vii+230. (London: Longmans and Co.) 7*s*. 6*d*. net.

Bartholomew's New War Map of Italy and the Balkan States. (Edinburgh: J. Bartholomew and Co.) 1*s*. net.

The Poison War. By A. A. Roberts. Pp. 144. (London: W. Heinemann.) 5*s*. net.

## DIARY OF SOCIETIES.

*FRIDAY*, JULY 2.

GEOLOGISTS' ASSOCIATION, at 8.—A Provisional Hypothesis to Explain the Occurrence of the Various Types of Fossil Man: Prof. A. Keith.

*SATURDAY*, JULY 3.

ARISTOTELIAN SOCIETY, BRITISH PSYCHOLOGICAL SOCIETY, and the MIND ASSOCIATION, at 6.—Joint meeting. Mr. Bertrand Russell's Theory of Judgment: Prof. G. F. Stout.

*MONDAY*, JULY 5.

ARISTOTELIAN SOCIETY, BRITISH PSYCHOLOGICAL SOCIETY, and the MIND ASSOCIATION, at 4.—Joint meeting. The Import of Propositions: Miss Constance Jones, Dr. Bernard Bosanquet, and Dr. F. C. S. Schiller.

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